A GAME THEORY BASED NEGOTIATION METHOD FOR DISPUTE RESOLUTION OF CONSTRUCTION PROJECTS

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ABSTRACT

A GAME THEORY BASED NEGOTIATION METHOD FOR DISPUTE RESOLUTION OF CONSTRUCTION PROJECTS

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Claims and disputes occur frequently in construction projects due to complex and dynamic nature of projects. Implementation of negotiating techniques is crucial to achieve a successful resolution of disputes in construction projects.

Within the context of dispute resolution processes, construction disputes can be resolved through various forms including negotiation, arbitration, and litigation. Their processes, particularly negotiation, mainly involve scrutinizing problem with the linguistic, behavioral and qualitative approaches. However, those approaches have a limitation for quantification of parties' liabilities for dispute resolution. This thesis presents a game theory based negotiation method that enables quantification of liabilities in the dispute resolution management. The main purpose of this study is to develop a negotiation method by which players can visualize and ascertain the possible outcomes of the dispute game in the assemble logic of qualitative and quantitative approaches in advance of arbitration or litigation. For this purpose, common dispute factors are determined from a comprehensive literature research. Then, analytic hierarchy process is utilized to rank and weigh importance of the causes, and game models are introduced in the negotiation theory, particularly, game theory. Finally, the dynamic structure of dispute game is obtained by following the

steps in the proposed negotiation method. One case study is used to illustrate contributions of the proposed method in dispute resolution management.

Keywords: Alternative Dispute Resolution, Dispute Causes, Analytic Hierarchy Process, Negotiation, Game Theory

ÖZ

İNŞAAT PROJELERİNDEKİ ANLAŞMAZLIKLARIN ÇÖZÜMÜNDE OYUN KURAMSALLI MÜZAKERE YÖNTEMİ

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İnşaat projelerinin karmaşık ve dinamik çalışma süreci, taraflar arasında birçok anlaşmazlığa sebep olabilmektedir. İnşaat projelerinin başarılı şekilde tamamlanması için anlaşmazlıkların müzakere ile sonuçlandırılması kritik önem taşımaktadır.

Uyuşmazlık çözüm yöntemleri kapsamında, inşaat uyuşmazlıkları; müzakere, tahkim ve mahkemeler de dâhil olmak üzere çeşitli şekillerde çözülebilmektedir. Müzakere yöntemi genel olarak, dilsel, davranışsal ve niteliksel yaklaşımlarla sorunları incelemeyi içermektedir. Bununla birlikte, müzakere yönteminde tarafların uyuşmazlık çözümüne ilişkin niceliksel yükümlülüklerinin belirlenmesi konusunda önemli eksiklikler vardır. Bu tez, inşaat anlaşmazlığı çözüm yönetimine, tarafların yükümlülüklerinin miktarının belirlenmesiyle birlikte oyun kuramsalını kapsayan bir müzakere yöntemi sunmaktadır. Bu çalışmanın temel amacı, tahkim ya da dava süreçlerinin öncesinde nitel ve nicel yaklaşımların mantığında, anlaşmazlık oyununun olası sonuçlarını görselleştirip, tarafların kullanabilecekleri bir müzakere yöntemi geliştirilmesidir. Bu doğrultuda, ortak anlaşmazlık faktörlerinin belirlenmesi için kapsamlı literatür taraması yapılmıştır. Anlaşmazlık sebeplerinin önem sırasını ve ağırlıklarının belirlemek için analitik hiyerarşik yöntemi kullanılmıştır. Tez kapsamında geliştirilen oyun kuramsallı müzakere yönteminin adımları ile anlaşmazlık oyunun dinamik yapısı elde edilmiştir. Anlaşmazlık çözüm yönetimi için önerilen metodun katkıları bir anlaşmazlık örneği ile gösterilmiştir.

Anahtar Kelimeler: Alternatif Uyuşmazlık Çözümü, Anlaşmazlık Sebepleri, Analitik Hiyerarşi Süreci, Müzakare, Oyun Teorisi

To My Beloved Father and Son

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CHAPTER 1

INTRODUCTION

Construction projects which mainly consist of project-based activities, have complex and dynamic nature due to involvement of multi-parties, different disciplines and tasks in it. Participants of professionals with different level of knowledge, experiences, and expectations in the multi-disciplinal structure of the project may cause disputes during complex working process. McManamy (1994) state that the complicated and proctracted procedure of contruction activities causes development of disputes inevitable. Thus, unlike other sectors, construction industry is subject and prone to more dispute cases. In the last few decades there is a considerable increase in disputes in the construction projects. In parallel with the increasing number of disputes in working process of construction, the necessity of effective dispute resolution becomes more and more crucial for successful completion of the construction project.

The dispute resolution process for construction projects can be carried out through litigation or some alternative dispute resolutions (ADR) methods. Negotiation, mediation and arbitration are common alternative dispute resolution methods. Due to high cost of arbitration and litigation, participants in construction disputes are searching options for dispute settlement negotiation (Sander et al., 2005).

The course of the adversarial action in litigation and arbitration could harm sustainable relationships among parties working together under an agreement. Alternative dispute resolution processes dependent on willful, non-adversarial techniques could result in a win/win solution to problematic issue, which helps parties to sustain business and working relationships (Yates, 2011).

Moreover, in order to end dispute satisfactorily the parties should not lose any claim that they deserve in the disputes. On the other hand, the contractor and the owner most of the time may not be aware of a proper method that could resolve their dispute. Typically, if the parties cannot reach a resolution themselves, litigation, which is expensive, time-consuming and traditional resolution mechanism, begins, which severely affects all the participants. The highly increasing cost, delay and risk of litigation's outcomes in construction disputes lead construction players search new and more efficient ways to deal with disputes outside the courts. Alternatively, disputes can be resolved more quickly and at less cost. Hence, there is a need for research and development of user-friendly method to execute the negotiation process and to resolve the disputes objectively and amicably under different scenarios.

Ren et al. (2003) states that negotiation is considered as the initial step to preserve amicable relationships between parties to fullfil the claim before the utilization of other disputes strategies methods such as arbitration, litigation etc. and prevent dispute from turning into extra cost, delay and unfavorable risk of litigation's outcomes. For a successful and effective alternative dispute resolution, the choices of right background negotiation theories and principles are requirements, which can shape the essential rules of the procedure. Moreover, the choice of proper analysis method for ranking importance of causes of dispute are important and essential (Dağkıran, 2015).

One of the gaps in the area of construction dispute management, particularly in negotiation process is that quantification process of parties' liabilities are not integrated into the qualitative negotiation plan in the resolution of dispute. In practice, more concrete, objective, scientific and systematic way of analyzing is necessary for dispute resolution management from the construction engineering perspective. Ranking importance of dispute factors and their way of correlations are prerequisite to show the causal relationships with a certain level of accuracy for dispute subject matter. In addition, the hierarchy of dispute factors should be analyzed and assessed objectively and consistently to resolve the issue in a righteous way, which may reduce the tension between participants in a dispute. There are some studies reviewed in the literature and described in the folowing chapters that those explains the significance of dispute factors, analytical hierarchy process and negotiation theories in dispute resolution of construction projects seperately. However, previous studies in the litrature do not develop a system, or a method that considers systematic and scientific quantification of the factors and evaluate the dispute subject matter based on one of negotiation theories called game theory. In fact, in the scope of proposed method, those three main research areas are assembled and conceptualized with five sequantial steps shown in Figure 5.1 in the following pages. A negotiation is proposed herein which can be useful for resolution of dispute cases.

In this thesis, a game theory based negotiation approach is presented in order to predict potential outcomes and obtain projections of possible outcomes in the dynamic structure of disputes. Particularly, the game theory based negotiation model is selected as a core model to analyze construction disputes in an attempt to ascertain possible outcomes during the negotiation or prior to arbitration or litigation. The proposed game theoretic negotiation method consists of several steps. Firstly, construction dispute causes are defined. Then, causes of disputes are categorized into variables as main and sub-categories. Next, the comparison of variables and elements of sub-categories are depicted and evaluated through Analytic Hierarchy Process (AHP) by participants' assessment. After obtaining ranking importance of dispute causes, quantification process of dispute responsibilities is measured by the players' assessment over the dispute causes. The quantification of distribution of parties' liabilities then becomes input for constructing dynamic structure of dispute game model. The proposed game theory based negotiation method is presented to enable the parties of dispute to determine the best strategies so that the players could also participate in negotiation table at a definite time for dispute settlement.

In this thesis, the chapters are organized as follows;

In Chapter 1**,** The main objective of the study is given, and the game theoretic negotiation model is described briefly.

In Chapter 2**,** Literature on construction dispute causes is reviewed; comprehensive list of causes of dispute is obtained.

In Chapter 3, Analytical Hierarchy Process (AHP) is described; practicability of AHP in various fields is described, and methodology of AHP is explained in detail.

In Chapter 4, Literature on negotiation theories; game theory is particularly researched, 2*2 game models are introduced and types of negotiation explained.

In Chapter 5, The methodology of game theory based negotiation approach in dispute resolution of construction projects is described.

In Chapter 6, Case study is presented with discussion: Application of steps for proposed game theoretic negotiation approach in the analysis of dispute are mentioned.

In Chapter 7, Study contributions, limitations, and future study directions are included.

CHAPTER 2

LITERATURE ON CONSTRUCTION DISPUTE CAUSES

2.1. Introduction

Dynamic, competitive and multiparty nature of construction projects can cause complex and various disputes. Disputes become an inherent characteristic of the construction sector as a reality. Any party in construction industry is inevitably involved in dispute cases to some certain extent. Moreover, many studies are available to demonstrate magnitude of the negative effects of disputes. Dispute are disruptive events that could bring about increasing costs, mostly in financial terms but sometimes negative impacts such as loosing reputation and relations, highly opportunity cost for possible works, distraction on parties' focus and waste too much time on legal issues and procedures. Thus, it is significant to scrutinize and define causes of disputes distinctly and be aware of them to figure out the most proper decision making process for effective dispute resolution.

2.2. Evolution of Dispute

It is obvious that there are many uncertain and unknown factors at the beginning of the project. Exposure to probable of occurrence of those factors could unfavorably result in negative consequences in the project, called construction risk (McCallum, 2000). Successful completion of projects depends on assessment and manageability of those risks. Inability to identify and evaluate those risks would cause conflicts. Similar to the risks, if those conflicts are not managed clearly and effectively, they become claims. Claims are serious disagreement and should be cautiously taken in hand and resolved through official procedures. Finally, if claims are not resolved, dispute occasions appear. Formation of dispute, called risk-conflict-claim-dispute continuum process, is illustrated in Figure 2.1 (Acharya et al., 2006).

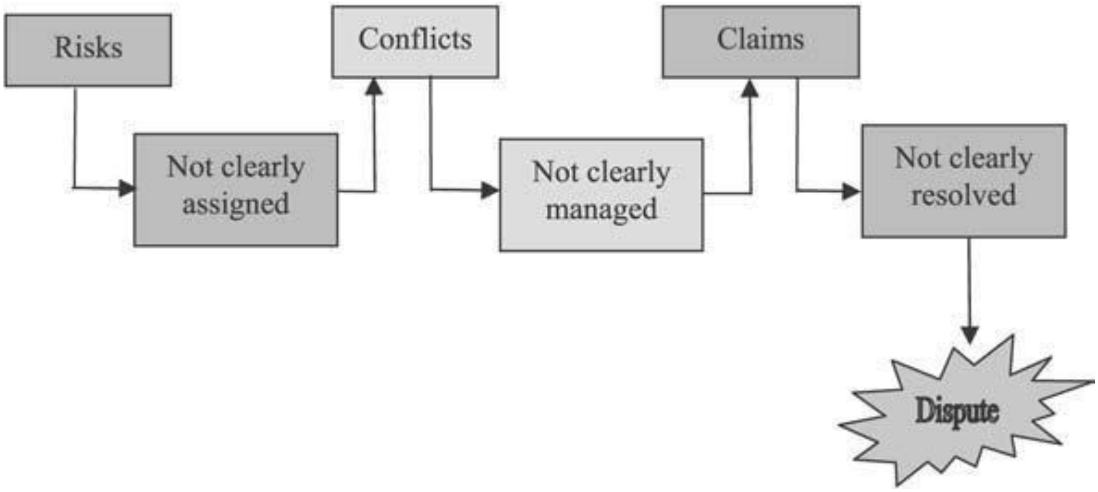


Figure 2.1. Risk-conflict-claim-dispute continuum model (Acharya et al., 2006)

2.3. Participants in Construction Disputes

In construction disputes, participants can be owner, contractor, architects /engineers, lawyers and experts. Each of those could have different attitude and perspectives, and consequently they could take positions differently in dispute resolution management.

2.3.1. Disputes from Contractor's View

Contractors are faced with numerous risk event or factors resulting in disputes at the end. Profitability of project could decrease dramatically due to consequences of unfavorable factors. However, willingness of contractors to be a player in the project makes them think optimistically for taking risks. In addition, contractors often request all-inclusive claims at the end of the project, which generally resulting in confrontational negotiation, which undermines probable collaboration between participants in the dispute resolution process.

2.3.2. Disputes from Owner's View

Owners are usually in charge of overall risks in the construction projects. Thus, owners have usually concerns about failure of contractor to satisfy the requirements of project stipulated in contract documents. To illustrate, reasons of owner claims against contractor include; defective works, not pay to official sub-contractors, costs because of contractor's suspension or inability to complete works on time. If those issues not resolved promptly, dispute is inevitable in which owners seek insurance, warranty for any damages incurred by contractor.

2.3.3. Disputes from A/E's View

In general, disputes due to design related factors are mainly design errors, omissions and complexity. A/E should satisfy technical requirements specified in the contract. Otherwise, depending on contract type and delivery method, A/E is liable for any design negligence and damages for malfunctioning process of works system pre-during-post construction phases. In such cases, owner, contractor, even insurance companies recourse to costs, damages incurred by A/E because of inadequate designs of the project (Lessani, 2016).

2.3.4. Disputes from Lawyer's View

Participants of dispute typically hire lawyers where litigation phase just begins. In general, players and engineers in disputes do not trust and like lawyers an account of nature of lawyers' business, prone to become competitive and attempting to make more profit with desired outcomes in litigation to win (Daicoff 1997). Moreover, a lawyer may define the words "win" or "success" in contrast to the engineer. Accomplishment of lawyer might be "winning" and getting the most concessions from opponent player, or as such, not losing (Galloway, 2013). In contrast, there is a reality that lawyers attempt to reach the best outcomes for their owner to catch attention more customers and make more profit by reputation in the long term (Lessani, 2016).

2.3.5. Disputes from Expert's View

Experts try to find the supporting facts through delicately working on the case and present those facts through un/official report in order to enable participants of dispute to determine and quantify financial credibility of the dispute items. Experts can charge their owners for dispute case-specific or an hourly rate fee. Experts' findings can be very crucial input data in litigation period as well as other dispute resolution processes (Lessani, 2016).

2.4. Dispute Causes in the Construction Industry

In dispute resolution management, determination of dispute causes is the first step to make a proper and objective analysis of any serious disagreement case. In literature, there are overabundance researches, which specify the causes of disputes in construction industry. A comprehensive literature review was conducted to form a general and generic catalog for causes of construction disputes.

Heath et al. (1994) examined a case study to determine main categories of claims and types of disputes in the UK. According to their study, seven main types of disputes are listed; contract conditions, payments, changes, extensions of time, nominations, re-nomination, and availability of information.

Mitropoulos and Howell (2001), in their study, method for understanding, avoiding, and resolving issues, fundamental factors that bring about the evolution of disputes are project uncertainty, contractual problems, and opportunistic behavior. Their proposed method specifies mainly four steps in which actions might be considered to prevent disputes and/or not allow their costs to increase: decrease in project uncertainty, decrease in contractual problems, ability to resolve problems in project organization and use of alternative dispute resolution methods.

Diekmann and Girard (1995) classified project characteristics of disputes into three main category; people, process, and project. Those play an important role in predicting the possibility of contractual disputes. Essentially, they tried to develop an approach to specify dispute-prone projects so that participants can take precautions to alleviate the possibility of experiencing contract disputes. However, in their research, primary conclusion is that "people" hold the key to avoiding contract disputes.

Watts and Scrivener (1992) studied various dispute classifications known from building dispute judgments in supreme courts of New South Wales and Victoria from. The purpose of their study is to ameliorate documentation and administration procedures used in the building industry. In their study, the most frequent dispute causes arise from variation, negligence in. tort, damages, delays

Semple et. al. (1994) studied construction claims and disputes to identify some of significant factors in construction projects. The six general classification of dispute are premium time, equipment costs, financing costs, loss of income, loss of efficiency, site overhead. Moreover, four primary causes of claims are identified; acceleration, restricted access, weather/cold, increase in scope. Objective of this paper is to help industry practitioners to pay attention the factors to minimize the risks of contract disputes.

Rhys Jones (1994) distinguished primary drivers of of disputes; poor management, confrontational culture, poor communications, lack of design, financial condition, unrealistic tendering, influence of lawyers, unreasonable owner desires, deficient contract drafting, poor workmanship. Hewitt (1991) identified six main factors resulting in construction disputes; changes in scope, changing conditions, delay, disruption, acceleration, terminations.

Bristow and Vasilopoulos (1995) studied disputes factors in Canadian construction sector. There are five primary causes of disputes are identified; unreasonable desires by parties, not clear contract documents, poor communications between project parties, lack of team spirit, incapable of participants to promptly overcome variations and undesired outcomes.

Gunduz et al. (2013) qauntified delay factors using the ranking importance index approach for in construction projects in Turkey. Delay is one of the most critical dispute factor between parties in the industry. Ranking of the factors and groups were calculated in respect of their importance significance level. Therefore, their study points that understanding of causes and importance ranking of delay factors could help parties to reduce number of possible future disputes. They illustrated 15 most important factors causing delays are considered as a causes and added to identified common dispute causes.

Colin et al. (1996) revealed six primary dispute areas contributing to development of dispute cases; installment and budget, execution, delay and time, carelessnes, quality, administration. Their objective is also to obtain general categories with common and important dispute causes to mitigate or reduce effects of the construction dispute or prevent it from beginning stage.

Cheung et al. (2006) studied that construction disputes can be classfied by the co-existent of three components; contract provision, triggering events, and conflict. Triggering events are non-performance, payment, time. Conflict arises from task interdependency, differentiations, communication obstacles, tensions, personal traits. Contract arrangement is defined as a fundamental occasion not to be developed further as practically all disputes have a legally binding reference. By considering the occurrence of construction dispute analogically as a system failure, the three dispute ingredients are framed in an FT model. The results demonstrates that the occurrence propability of construction disputes is inevitable. This shows that construction professionals should develop proactive approach in dispute resolution management. This includes developing skills to prevent dispute where dispute arises, to solve them through assisted or unassisted negotiations. Therefore, negotiation is considered to be the Best Alternative to a Negotiated Agreement.

Another study conducted by Kumaraswamy (1997) is mainly used as a framework in the clustering of common causes of disputes. Author identified the general causes of disputes in construction, to seperate and govern the root causes. Identification of such root causes will be beneficial in resolution of any ongoing and unavoidable disputes. In addition, management can focus to anticipate and avoid common issues, thereby improving dispute resolution management and developing effective dispute minimization.

In this regard, purpose of this chapter is to identify and cluster the most common dispute factors in a framework from a literature review. The findings of the research that are mentioned in the literature review are summarized in Table 2.1. This study does not focus or anticipate dispute factors and take precautions in the construction works or use them for preventing dispute in advance or make prioritization among them. Instead, participants involved in dispute case can search the clustering catalog to ameliorate understanding of probable and possible causes of dispute for the subject matter in specif case, thereby improving their proper selection of objective criteria. Precisely, any causes of disputes evaluated and selected from the catalog increase the awareness of participants or parties, which yields better and more objective assessment for case-specific dispute settlement negotiation. In other words, the objective of clustering common causes of disputes in a framework is not to give full list of the dispute causes satisfying all disputes within certain extent. On the other hand, any participant in dispute resolution process can benefit from it as much as possible to form best hierarchy of the causes or determine factors to make a proper analysis of the dispute.

Table 2.1. *Summary of the Literature on the Causes of Construction Disputes*

IDENTIFIED COMMON DISPUTE CAUSES		
Main Categories	**Sub-categories**	**Sources**
Owner /Owner	Change orders	Heath et al. (1994), Watts and Scrivener (1992), Kumarasamay (1997), Hewitt (1991), Yiu and Cheung (2007)
	Interim payment delays	Kumarasamy (1997), Conlin et al. (1996), Hewitt (1991)
	Acceleration	Semple et. al. (1994)

IDENTIFIED COMMON DISPUTE CAUSES		
Main Categories	**Sub-categories**	**Sources**
	Slow or unauthorized decision making	Fenn et al.(1997), Rhys Jones (1994)
	Unrealistic imposed expectations	Bristow and Vasilopoulos (1995), Yiu and Cheung (2004), Rhys Jones (1994)
	Owner Interference	Kumaraswamy (1997)
	Delay in approving design documents	Chan and Kumaraswamy (1997), Hall (2002), El Razek et al. 2008).
	Delay in site handover	Fenn et al. (1997), Gunduz et al. (2013)
	Lack of capable representative	Gunduz et al. (2013)
	Suspension of work by owner	Gunduz et al.(2013)
	Improper project feasibility study	Gunduz et al.(2013)

IDENTIFIED COMMON DISPUTE CAUSES		
Main Categories	**Sub-categories**	**Sources**
	Lack of experience in construction projects	Gunduz et al.(2013)
Contractor	Inadequate contractor experience in planning and controlling	Fenn et al.(1997), Dikmen et al. (2007)
	Incompetent project team	Carmicheal(2002), Rhys Jones (1994),
	Delay in work progress	Odeh and Battaineh (2002), Chan and Kumaraswamy (1997), Yiu and Cheung (2004),Hall(2002)
	Insufficient financial sources of the contractors/their cash flow	Kumarasamy (1997), Mitropoulos and Howell (2001)
	Poor communication and coordination with other parties	Rhys Jones (1994), Bristow and Vasilopoulos (1995), Chan and Suen (2005), Diekmann et al. (1994)
	Lack of technical capability	Fenn et al.(1997),Gunduz et al.(2013)

IDENTIFIED COMMON DISPUTE CAUSES		
Main Categories	**Sub-categories**	**Sources**
	Poor site management and supervision	Carmicheal(2002), Rhys Jones (1994), Cheung et al. (2006)
Design	Low quality of design; design errors & omissions	Hall(2002), Acharya and Lee (2006) ,Rhys Jones (1994)
	Design changes by owner or his agent during construction	Acharya and Lee (2006)
	Inadequate / incomplete specifications	Hall(2002), Heath et al. (1994), Acharya and Lee (2006)
	Insufficient data collection and survey before design	Gunduz et al.(2013)
	Inaccurate site investigation	Gunduz et al.(2013)
	Project design complexity	Gunduz et al.(2013)
Project	Ground conditions /site conditions	Acharya and Lee (2006)

IDENTIFIED COMMON DISPUTE CAUSES		
Main Categories	**Sub-categories**	**Sources**
	Unforeseen changes	Heath et al. (1994), Acharya and Lee (2006)
	Estimating Errors	Hall(2002)
Materials	Wrong selection of construction materials	
	Changes in material types and specifications	Chan and Kumaraswamy (1997)
	Quality of material	Chan and Kumaraswamy (1997), Conlin et al. (1996), Gunduz et al. (2013)
	Poor procurement of construction materials	Gunduz et al.(2013)
Labor	Labor shortage	Chan and Kumaraswamy (1997), Gunduz et al.(2013)
	Low skill levels, unqualified, inexperienced workers	Chan and Kumaraswamy (1997), Gunduz et al.(2013)
	Strike	Chan and Kumaraswamy (1997), Gunduz et al.(2013)

IDENTIFIED COMMON DISPUTE CAUSES		
Labor	Slow mobilization of labor	Chan and Kumaraswamy (1997), Gunduz et al.(2013)
	Low worker productivity	Semple et. al. (1994), Chan and Kumaraswamy (1997)
Plant/Equipment	Shortages	Chan and Kumaraswamy (1997),Gunduz et al.(2013)
	Low efficiency	Chan and Kumaraswamy (1997), Gunduz et al.(2013)
	Breakdowns	Chan and Kumaraswamy (1997), Gunduz et al.(2013)
	Wrong selection, improper equipment	Chan and Kumaraswamy (1997), Gunduz et al.(2013)
Human	Lack of communication	Fenn et al.(1997), Rhys Jones (1994), Bristow and Vasilopoulos (1995)
	Opportunistic Behavior	Mitropoulos and Howell (2001)
	Negligence of project participants	Acharya and Lee (2016), Colin et al. (1996)

IDENTIFIED COMMON DISPUTE CAUSES		
Contract	Ambiguities and conflict in contract documents and different interpretations of the contract provisions	Cheung and Yui (2006), Carmicheal(2002), Heath et al. (1994), Mitropoulos and Howell (2001), Carmicheal(2002)
Other Factors	Weather condition	Semple et. al. (1994)
	Legal issues; Changes in regulations and laws	Gunduz et al.(2013)
	Price fluctuations	Gunduz et al.(2013)
	Environmental concerns and restrictions.	Semple et. al. (1994)
	Differing Site Condition; Surface and subsurface conditions	Acharya and Lee (2006), Diekmann and Nelson (1985), Kumarasamy (1997)
	Delay in obtaining permits from municipality or any official entity.	Gunduz et al.(2013)
	Strike	Gunduz et al.(2013)

CHAPTER 3

ANALYTIC HIERARCHY PROCESS

3.1. Definition

Selection of correct and important factors in making a decision in dispute resolution management is very critical task. In the analytic hierarchy process, selection and organization of criteria from an overall objective to criteria, sub-criteria are descending in a structured form within successive levels (Saaty, 1990). It is widely accepted and utilized in application for multiple criteria decision process (Ho, 2007). Particularly, AHP is a multi-criteria decision-making process to resolve complex and unstructured decision issues, particularly in cases where there are significant qualitative evaluation that should be organized in conjunction with the range of measurable quantitative factors (Khanzadi et al., 2009). In other words, Skibniewski et al. (1992) described power of this method, which enables users to coordinate tangible and intangible factors in a solution systematically for decision-making issues.

In this study, AHP is used to obtain quantification of distribution of parties' responsibilities while considering to dispute factors as qualitative matters taking into consideration in conjunction with the range of measurable quantitative factors. AHP is used for measurement of parties', experts' beliefs over the dispute elements. It forms objective default assessments of causes, which leads parties, decision makers to obtain distribution of parties' liability for specific case. Liability distribution can be defined as the probability of the plaintiff being responsible for that dispute in arbitration or at the court. In other words, the partial damages cost that the defendant will be responsible for or the unexpected expenses plaintiff may have afforded because of the defendant's alleged fault. Causes of dispute are classified into man and/or main sub-categories, and AHP model provides structure pattern which help to determine contribution of each factor causing dispute. Quantification of parties' liability becomes reservation points in the geometry of negotiation zone as shown in Figure 4.1, and become important parameter for constructing dynamic structure of dispute game.

3.2. Practical Use of AHP in Construction Industry

In literature, there are several applications describing practical use of AHP for different purposes in various areas such as management, engineering, industry.

Dikmen and Birgonul (2006) proposed an analytic hierarchy process based model in the assessment of international construction projects with respect to risk and opportunity criteria. That is, the model uses AHP for calculation of risk and opportunity ratings. Aminbakhsh et al. (2013) utilized analytic hierarchy process in safety risk assessment of construction projects during planning and budgeting. Authors described identification of probable hazards and evaluation of the risks related with those hazards in the safety risk assessment by ranking of safety risks with usage of AHP during planning, budgeting, and management of safety.

Chua et al. (2002) identified critical success criteria, sixty-seven success-related criteria, for construction projects. The analytic hierarchy process enable users to rank important success related criteria, and determine these factors with respect to the project targets; budget, schedule, and quality. A hierarchical model was presented, which satisfy construction project success through categorization of main project aspects, specifically, project characteristics, contract provisions, project participants, and interactive processes for project success.

Cakmak and Cakmak (2013) used AHP to specify the primary causes of disputes in the construction sector. Authors classified disputes into main and sub-categories for the causes. Finally, an analysis uses the analytical hierarchy process (AHP) to decide their ranking significance of factors. Moreover, Soni et al. (2017) evaluated factors mostly responsbile for conflicts and dispute in construction projects by AHP technique. Similar to Cakmak and Cakmak study, they conducted a literature survey to obtain factors which lead to dispute. Ranking importance of factors were calculated and they proposed that mainly top five factors which are ambuguity in contract documents, delay in payment, delay in projects due to contractor, insufficient information and contractor financial failure should be managed meticulously. On the other hand, those studies obtained a generalized ranking importance of the dispute causes. In fact, it is not realistic to use generalized weights of dispute causes for all dispute cases.

Barchiesi and Costa (2014) concluded that conflict resolution was enhanced through an AHP-based methodology. Particularly, they proposed a methodology to improve dispute resolution based on the AHP and consider psychological behavior of the conflicting parties. The AHP technique is used to asist a neutral party in choosing, among possible negotiation settlements, those proposals with the highest probability to be admitted by conflicted parties. In fact, the decision makers can simply and more precisly express his/her own assessment on the relationship between couples of elements in the same cluster with respect to the common parent and rank importance of negotiation possible demands.

Fong and Choı (1999) used AHP for selection of proper contractor in the final stage of bidding process. A hypothetical scenario formed and tested, in which three contractor candidates are considered. Importance of factors were obtained through a questionnaire survey. Relative importance of factors are determined with comparisons by which ranking value of each candidate in regard to their performance with respect to each of the criteria, and the candidate with the highest value is considered as the most valuable contractor on this incident. Similar to this study, Al-Harbi (1999) considered AHP in the project management for contractor prequalification problem. The prequalification criteria structure was formed for contractors willing to end up the project satisfactorily. Obtaining ranking of the prequalification criteria with the usage of AHP, and a descending-order list of contractors was illustrated to select the best contractors to perform the project.

3.3. Theoretical Background of AHP

There are mainly three operational components of AHP, hierarchy structuring, priority analysis, and consistency check. In hierarchy construction, the decision problem is usually broken down into sub-components, each of which is analyzed independently. After forming hierarchy, decision makers assign a numerical intensity scale to each pair of *n* options. In the same level, pairwise fashion is created by participants' background experience and knowledge. Since experts have subjective judgments in the comparisons of component parts, some degree of inconsistency might come out. Therefore, consistency verification in AHP is prerequisite and final step is to crosscheck consistency of the judgments by measuring the level of consistency among the pairwise comparisons by calculating the consistency ratio. In case of exceedance of consistency ratio limit, experts should reconsider the pairwise comparisons. Then, if all pairwise comparisons satisfying consistency limit, ranking importance of dispute factors was obtained by considering the given judgements (Ho, 2007).

3.3.1. Pairwise Comparison, AHP Scale and Matrixes

Experts, professionals or decision makers with well-qualified experiences and knowledge are mainly involved in the evaluation of factors in hierarchy structure. On the other hand, the factors with interstitial connection within this constructed structure can be complex or not assessed effectively if scoring out factors numerically. Hence, in Table 3.1, AHP scale proposed by Saaty (1994) is used to convert qualitative judgements into numerical expression in order to assess the criteria more systematically and rationally. In this process, the most significant parts are structuring the subject issue and forming the hierarchy. While constructing the hierarchy, participant is able to rank the significance of factors in each level of the hierarchy. Those factors are compared in respect of their significance in each pairwise level. Pairwise comparison matrix is evaluated in the range of 1 to 9, and each definition of weights is given in Table 3.1.

Table 3.1. *AHP Pairwise Comparison Scale (Saaty, 1994)*

Intensity scale	Definition	Verbal explanation
1	**Equal importance** of the two elements	Two elements contribute equally to the objective
3	**Moderate importance** of one element compared to another	Experience and judgement slightly favor one activity over another
5	**Strong importance** of one element compared to another	Experience and judgement strongly favor one activity over another
7	**Very Strong importance** of one element compared to another	An activity is favored very strongly over another, its dominance demonstrated in practice
9	**Extreme importance** of one element over another	The evidence favoring one factor over another is of the highest possible order of affirmation
2,4,6,8	**Intermediate values for compromise** between two neighboring levels	The assessment falls between two levels
Reciprocals (1/x)	A value attributed when activity i is compared to activity j becomes the reciprocal when j is compared to i	

According to Saaty and Özdemir (2003), for a couple of *n* alternatives (A*i*, A*j*) square matrices are constructed. The numerical values are obtained from AHP comparison scale, and $a_{i,j}$ demonstrates comparative significance of criterion i with regard to criterion j. Lower-left values is the reciprocals of upper right values in the matrix, which means that $a_{j,i} = 1/\ a_{i,j}$. The complete matrix is given Equation 3.1.

$$A = \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ \frac{1}{a_{12}} & 1 & \cdots & a_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ \frac{1}{a_{1n}} & \frac{1}{a_{2n}} & \cdots & 1 \end{bmatrix} \qquad \text{Eq. 3.1}$$

Saaty (1990) used the maximum eigenvalue approach to obtain the comparison matrices as: $A.p = \lambda_{max} w$ where; λ_{max} is the max-eigenvalue of matrix A.

Incompatibility of the matrix A could not be more than 0,1 and the consistency of assessments can also be checked with consistency ratio (CR) given Equation 3.2.

$$CR = \frac{CI}{RI} \qquad \text{Eq. 3.2}$$

where Random Index (RI) is a number changing with respect to the size of the matrix and Consistency Index (CI, given in Equation 3.3) (Table 3.2).

Table 3.2. *Random Consistency (RC) Index Table, RI*

Order	1	2	3	4	5	6	7	8	9	10
RI	0	0	0,52	0,89	1,1	1,25	1,35	1,4	1,45	1,49

$$CI = \frac{\lambda_{\max} - n}{n-1} \qquad \text{Eq. 3.3}$$

where is *n* specified as the number of evaluated criteria and $\lambda_{\max}$ is given in Equation 3.4.

$$\lambda_{\max} = \frac{\sum_{j=0}^{n} (a_{ij} wj)_i}{w_i} \qquad \text{Eq. 3.4}$$

and where A is the factor placed in a specific row and column, and w is the weighted average of a particular row.

In dispute resolution cases, there could be more than one experts' opinion in a different range of assessment of the factors. Different evaluation in scoring out factors using AHP comparison scale might cause group inconsistency to the some certain extent. Therefore, various ideas for the factors' assessments with different range of intensity importance value need to be integrated properly. Particularly, every evaluation and contribution should be taken into consideration and integrated in decision making process. Saaty (2008) proposed geometric mean of corresponding matrixes for the combination of all different level of contributions of decision makers (Equation 3.5

and 3.6). In fact, extreme and irrelevant assessments impacts are limited and neutralized.

$$a_{ij} = \sqrt[n]{(a_{ij1} \times a_{ij2} \times ..... \times a_{ijn})} \qquad \text{Eq. 3.5}$$

$$B = \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ a_{n1} & an2 & \cdots & a_{nn} \end{bmatrix} \qquad \text{Eq. 3.6}$$

The term a_{ijk} is the choice of expert k considering option a_i compared to option a_j. After the complete expert assessments are obtained and calculated using the geometrical mean, they are integrated into the pairwise comparison matrix B. However, it may yield unsatisfactorily results even not be noticed in the factors weights due to ignorance of each expert's consistency ratio effect. Instead, Wu et al. (2011) revised AHP for group decision making. Different decision makers, experts could have various criteria preferences in which their consistency ratio could also be different. Hence, finding a solution to give a certain weight for each expert is requirement. Firstly, the pairwise comparison matrix A= $(a_{ij})_{m*m}$, and the corresponding consistency ratio CR_k^t are obtained by analytic hierarchy process. t $(1 \leq t \leq T)$ is the couple of pairwise matrix in analytic hiearachy process decided by each expert, k $(1 \leq k \leq n)$ is the number of the experts. Then, the k^{th} expert weight P_k is computed by the following Equations 3.7 and 3.8.

$$P_k^t = \frac{1}{1 + \alpha CR_k^t} \qquad (\alpha > 0, 1 \leq k \leq n, 1 \leq t \leq T) \qquad \text{Eq. 3.7}$$

$$P_k^t = \frac{\sum_{t=1}^{T} p_k^t}{T} \qquad (1 \leq k \leq n,\ 1 \leq t \leq T) \qquad \text{Eq. 3.8}$$

The variable α is too large or too small; the expert weight is difficult to be distinguished. Hence, practicable value of α is generally accepted as 10 to propose moderate distinguishing impacts and straight stability. Finally, the expert weight * P_k obtained by normalizing Equation 3.8 as follows:

$$P_k^t = \frac{p_k}{\sum_{k=1}^{n} p_k} \qquad (1 \leq k \leq n) \qquad \text{Eq. 3.9}$$

The last index weight is obtained based on root index weight W_i^t $(1 \leq i \leq m)$ by AHP, and considered of expert weight P_k^*. This approach foremost follow AHP to obtain the root index weight W_i^t, and then takes expert weight P* in-group decision-making into account. The final index weight is given in Equation 3.10.

$$W_I = \sum_{k}^{n} w_{i.}^{k} . p_k^* \qquad (1 \leq k \leq n, 1 \leq t \leq m) \qquad \text{Eq. 3.10}$$

In the end, the index weight W_i^* of the i_{th} index is normalized (Eq. 3.11).

$$W_I = \frac{W_i}{\sum_{i=1}^{m} W_i} \qquad (1 \leq i \leq m) \qquad \text{Eq. 3.11}$$

Particularly, revision is made in AHP to integrate different experts' opinion to assess final index weight is to prevent various decision-making choices by experts. The approach forms objective judgement in decision matrix.

Two examples are given to demonstrate CR calculation clearly, one of which is for one expert, the other one is for more than one experts. The latter one follows Wu et al's (2011) revised AHP method.

3.3.1.1. Example for One Expert's Assessment

One expert for ranking importance of elements constructs a pairwise comparison matrix; calculations of steps are as follows,

Step1. Pairwise comparison matrix is named as A;

$$A = \begin{bmatrix} 1 & 5 & 1/3 & 1/3 \\ 1/5 & 1 & 1/5 & 1/5 \\ 3 & 5 & 1 & 1 \\ 3 & 5 & 1 & 1 \end{bmatrix}$$

Step2. ∑ Column Sum = [7.200 16 2.533 2.533]

Step3. Standardized Matrix

$$A = \begin{bmatrix} 0{,}138889 & 0{,}31250 & 0{,}131579 & 0{,}131579 \\ 0{,}027777 & 0{,}06250 & 0{,}078947 & 0{,}078947 \\ 0{,}416667 & 0{,}31250 & 0{,}394736 & 0{,}394736 \\ 0{,}416667 & 0{,}31250 & 0{,}394736 & 0{,}394736 \end{bmatrix}$$

Step4. $w = \begin{bmatrix} 0{,}138889+ & 0{,}31250+ & 0{,}131579+ & 0{,}131579 \\ 0{,}027777+ & 0{,}06250+ & 0{,}078947+ & 0{,}078947 \\ 0{,}416667+ & 0{,}31250+ & 0{,}394736+ & 0{,}394736 \\ 0{,}416667+ & 0{,}31250+ & 0{,}394736+ & 0{,}394736 \end{bmatrix} \quad w = \begin{bmatrix} 0{,}1786 \\ 0{,}0620 \\ 0{,}3797 \\ 0{,}3797 \end{bmatrix}$

Step5. $A.w = \begin{bmatrix} 1 & 5 & 1/3 & 1/3 \\ 1/5 & 1 & 1/5 & 1/5 \\ 3 & 5 & 1 & 1 \\ 3 & 5 & 1 & 1 \end{bmatrix} \begin{bmatrix} 0{,}1786 \\ 0{,}0620 \\ 0{,}3797 \\ 0{,}3797 \end{bmatrix} \quad A.w = \begin{bmatrix} 0{,}7417 \\ 0{,}2496 \\ 1{,}6054 \\ 1{,}6054 \end{bmatrix}$

Step6. $\lambda_{\max} = \dfrac{\dfrac{0{,}7417}{0{,}1786} + \dfrac{0{,}2496}{0{,}0620} + \dfrac{1{,}6052}{0{,}3797} + \dfrac{1{,}6052}{0{,}3797}}{4} = 4{,}1586$

Step7. $CI = \dfrac{4{,}1585 - 4}{4 - 1} = 0{,}052$

Step8. $CR = \dfrac{0{,}052829}{0{,}89} = 0{,}058 < 0{,}1$ Consistency achieved.

3.3.1.2. Example for Four Experts' Assessment (revised AHP method by Wu et al. 2011)

Table 3.3 and Table 3.4 demonstrate ranking importance of dispute causes assessed by four experts, simultaneously. To integrate each experts' assessment consistently, different from one expert's assessment, expert weight P normalized values are taken into account for group decision making. Those are computed after obtaining consistency ratio of matrices for each expert's assessment. That is, each expert weight is computed by above the equations 3.7, 3.8, 3.9, 3.10, 3.11. These matrices are created and evaluated, hypothetically.

To illustrate first expert's normalized P, calculations of steps are as followings,

Step 1. Modified and Unnormalized P_k,

$$CR_1 = 0{,}536$$

$$P_1 = \frac{1}{1+10*0{,}0536},\ P_1 = 0{,}6510 \qquad \text{Eq. 3.7}$$

Step 2. Sum of the P_k,

$$P_1 = 0{,}6510,\ P_2 = 0{,}6776,\ P_3 = 0{,}6732\ ,\ P_4 = 0{,}7664$$

$$\sum = P1 + P2 + P3 + P4,\ \sum_1^4 Pk = 2{,}7682 \qquad \text{Eq. 3.8}$$

Step 3. Normalized P_k

$$P_1^* = 0{,}2352,\ P_2^* = 0{,}2448,\ P_3^* = 0{,}2432\ ,\ P_4^* = 0{,}2769$$

$$P_1^* = \frac{0{,}6510}{2{,}7682} \qquad \text{Eq. 3.9}$$

Step 4. Normalized Index Weights for each cause

$$W_1 = 0{,}4855,\ W_2 = 0{,}2887,\ W_3 = 0{,}1292,\ W_1 = 0{,}0966$$

$$W_1 = P_1^*.CR_1 + P_2^*.CR_1 + P_3^*.CR_1 + P_4^*.CR_1$$

$$W_1 = 0{,}2352*0{,}4220 + 0{,}2448*0{,}5126 + 0{,}2432*0{,}5596 + 0{,}2769*0{,}4504$$

Table 3.3. *Details of Ranking Importance of Dispute Causes with AHP by four Experts*

exp1 matrix	1	2	2	4	**exp2 matrix**	1	3	3	5
	1/2	1	3	4		1/3	1	2	4
	1/2	1/3	1	1		1/3	0,5	1	1
	1/4	0,25	1	1		1/5	0,25	1	1
Column Sum	2,25	3,5833	7	10	**Column Sum**	1,8667	4,75	7	11
Standardized (Matrix)	0,4444	0,5581	0,2857	0,4000	**Standardized (Matrix)**	0,5357	0,6316	0,4286	0,4545
	0,2222	0,2791	0,4286	0,4000		0,1786	0,2105	0,2857	0,3636
	0,2222	0,0930	0,1429	0,1000		0,1786	0,1053	0,1429	0,0909
	0,1111	0,0698	0,1429	0,1000		0,1071	0,0526	0,1429	0,0909
Weights	0,4220	0,3324	0,1395	0,1059	**Weights**	0,5126	0,2596	0,1294	0,0984
A.w.	1,7897	1,386	0,5673	0,4341	**A.w.**	2,1715	1,0828	0,5284	0,3952
CR	0,0536				**CR**	0,0476			
				RI					RI
CI	0,0477			0,89	**CI**	0,0423			0,89
LAMDA max	4,143				**LAMDA max**	4,127			

exp3 matrix	1	4	4	5	**exp4 matrix**	1	2	3	4
	1/4	1	3	3		1/2	1	3	4
	1/4	1/3	1	1		1/3	1/3	1	2
	1/5	1/3	1	1		1/4	1/4	1/2	1
Column Sum	1,7	5,6667	9	10	**Column Sum**	2,0833	3,5833	7,5	11
Standardized (Matrix)	0,5882	0,7059	0,4444	0,5000	**Standardized (Matrix)**	0,4800	0,5581	0,4000	0,3636
	0,1471	0,1765	0,3333	0,3000		0,2400	0,2791	0,4000	0,3636
	0,1471	0,0588	0,1111	0,1000		0,1600	0,0930	0,1333	0,1818
	0,1176	0,0588	0,1111	0,1000		0,1200	0,0698	0,0667	0,0909
Weights	0,5596	0,2392	0,1042	0,0969	**Weights**	0,4504	0,3206	0,1420	0,0868
A.w.	2,4179	0,9825	0,4207	0,3928	**A.w.**	1,8652	1,3193	0,5727	0,3506
CR	0,0485				**CR**	0,03048			
				RI					RI
CI	0,0432			0,89	**CI**	0,02712			0,89
LAMDA max	4,130				**LAMDA max**	4,081			

Table 3.4. *Results of Ranking Importance of Dispute Causes with AHP by Four Experts*

	CR	**P_k**	**Normolized P_k**	**Weights**
Cause 1	0,0536	0,6510	0,2352	**0,4855**
Cause 2	0,0476	0,6776	0,2448	**0,2887**
Cause 3	0,0485	0,6732	0,2432	**0,1292**
Cause 4	0,0305	0,7664	0,2769	**0,0966**
		∑ 2,7682		∑ **1,0000**

CHAPTER 4

NEGOTIATION

4.1. Introduction

Participants involved in decision-making process try to anticipate effects of their own strategies on the behavior of others. Strong interactions and interdependency of individuals to each other bring about a stimulus for them to act strategically in disputes and conflicts situations (Romp, 1997). Given this reality, negotiation is the decision-making process where multi-participants seek various options with the aim of reaching an agreement (Rahwan et al 2004). Raiffa et al. (2002) stated that negotiation cases share four common characteristics:

(i) there is more than one party,
(ii) the participants might be intelligent to reach an agreement,
(iii) the payoffs to any party depend either on the results of agreement or options external to the negotiations,
(iv) the participants might reciprocally and directly exchange information, honest or not.

In the construction sector, preference of negotiation is significant for disputes settlement to minimize probable future loses; efforts, time, and costs. However, negotiation of construction disputes is not performed effectively by construction participants because of different level of intellectual background and experiences, involvement of many variables, dynamic of interactions, and insufficient knowledge for negotiation process. Effective negotiation is prerequisite to prevent construction participants from being involved in lengthy and expensive arbitration and/or litigation period. Thus, it is crucial to develop an effective negotiation approach in order to control disputes properly, improve proactive dispute management and decision-making strategies.

One of the gaps in the area of construction dispute management, particularly in negotiation process, is that systematical quantification process of parties' liabilities are not integrated into the qualitative negotiation plan in the resolution of construction dispute. Moreover, there is no study to analyze dispute game in an attempt to ascertain possible outcomes based on game theoretic negotiation approach during the negotiation, prior to arbitration or litigation according to parties' quantified liabilities in dispute management of construction projects.

Some studies mention the identification of root causes of dispute to anticipate and avoid common issues by which improving proactive dispute resolution management. On the other hand, clustering identified common dispute factors is not considered in the steps of quantification of parties' liabilities and predict the possible outcomes based on game theoretic approach in dispute management of construction projects.

Furthermore, there are some studies using AHP to identify primary causes of disputes in construction projects, and those studies proposes a general ranking importance of the dispute causes. However, they do not consider how AHP can be utilized in the steps of quantification of parties' liabilities and predict the possible outcomes based on game theoretic negotiation approach in any specific dispute cases of construction projects to obtain more scientific, systematic and objective evaluation.

Finally, game theory is used to illustrate the outcome of conflict and cooperation among the intelligent decision-makers as a result of their joint necessities in solving the construction project conflicts and in the project management of construction projects. On the other hand, there is no research that presents a common structure, thereby presenting probable participants' preferences and outcomes of the dispute game, and recognizing stages of dynamic structure of dispute game according to parties' quantified liabilities in dispute negotiation of construction projects.

As a result, previous studies in the literature do not develop a system, or a method that considers systematic and scientific quantification of parties' liabilities in dispute game and evaluate the dispute subject matter based on one of negotiation theories called game theory.

4.2. Negotiation Theories

Academician and professionals from different disciplines and background have developed various approaches to improve their understanding of negotiation parameters, process and types (Alfredson et al, 2008). According to Zartman (1978), there are five primary approaches; the structural, the strategic (game theory), the processual, the behavioral and the integrative approaches. Moreover, Ren et al. (2003) has pointed out that complexity, dynamicity of problems, human related questions in negotiation examined by various significant negotiation theories approaches including game theory, economic theory, and behavior theory.

Game theoretic approach is considered with two approaches, the axiomatic approach and the strategic approach. Some game theorists consider strategic approach as a component of economic theory. However, negotiation theorists oftenly differantiate game theory from economic theory (Ren et al., 2003). Game theory searches decision-making where the result of their cooperation and competition is product of their joint requirements and the coaction of individuals' self-interest. Different from the classical game theory, in economic theory there is no consideration for the settlement of once and for all strategies, but rather a plan to analyses how the bargainers are supposed to affect each other in respect of their expectations (Young, 1975). In behavioral approach, much concern exists in the variation of expectations and negotiators' tactics, and importance of obscurity of information, perception and assessment, all matters that prone to be overpassed by game theory and economic theory (Zartman, 1978).

In this study, game theory is chosen as a core negotiation theory and 2*2 game models, i.e., prisoner dilemma and chicken game are introduced and explained. Then, types of negotiation and their basics, which are prerequisite for development of unbiased and objective quantification of liability, are described. Finally, importance of negotiator is explained from engineering aspect.

4.2.1. Game Theory

Von Neumann and Morgenstern established game theory in their study called Theory of Games and Economic Behavior in 1944. Game theory is a derivative of economics and demonstrates strategic interactions among agents, leads to overall results with respect to agent's preferences (Rahwan et al., 2004).

Bacharach et al. (1981) state game theory as searching necessities of decision process and the related tactics in occasions in which participant are depended on each other. Moreover, Dixit and Skeath (2004) defined game theory as rational decision-making process in interactive situations. Therefore, the outcome of their conflict and cooperation among the intelligent decision-makers is the result of their joint necessities and coaction of their self-preferences (Myerson, 1991).

In the game theory technique individuals analyze dispute cases and calculate overall outcomes; hence, game theory is studied in assessment of different scenarios and strategies of partcipants (Kersten, 1997; Dağkıran 2016). Game theory has some basic assumptions and terminologies, useful for evaluation of outcome of dynamic structure of dispute which is explained in the Chapter 5.

4.2.1.1. Cooperative and Non-cooperative

Game theory uses specific terminologies to clear up the difference between cases whether agreements are enforceable or not. Joint-action agreements are binding and enforceable in a cooperative game. On the other hand, in non-cooperative game individuals are allowed to act in their own benefit and interests (Dixit and Skeath, 2004). In non-cooperative game, the individuals, or players, are not able to enter into binding and enforceable agreements with one another. It does not mean that non-cooperative game theory exclude the game where individuals are working together. However, it does describe that this will only happen if individuals perceive such co-operation to be in their own self-interest (Romp, 1997). Thus, disputes are usually stated as non-cooperative process between the players. In non-cooperative games, parties anticipate the payoffs conditional to the opponent's belief. When there is no assurance about the information, as in incomplete information games, each player thinks about their opponents' knowledge as well as their own knowledge on the parameters of the dispute case. Decision makers may also consider their opponent's knowledge about their own knowledge (Lessani, 2016).

4.2.1.2. The List of player

Primary players such as owner, general contractor, architect/angineer, (sub)contractor are key construction parties that are mainly involved in construction disputes. In this study, involvement of two parties (owner and contractor) in dispute game is considered in a normal form game.

4.2.1.3. Strategies

Every individual is aware of options, alternatives for development of own strategies. If purely simultaneous movements in a game are considered only once, action for that specific occasion is considered as each player's strategy. However, if sequential movements in a game are considered, then the actions of a player moving later in the game can react to what other individuals have done at earlier stages. Hence, individuals must consider a full plan of action, for instance: "If opponent does A, then I follow action X but, if the opponent does B, then I follow Y." This full plan of action forms the strategy in such a game (Dixit and Skeath, 2004). As an example, contractor's action can be submitting a claim and requesting an agreement. The owner's action could be rejecting claim and responding to counter proposals.

4.2.1.4. Payoffs

Player's payoff is an outcome, which is quantified by gain for each probable outcome. Higher payoff values related to that outcome means a better gain in the system range. Generally, numerical rating of results of strategies can be described as payoff. On the other hand, there could be different types of outcomes such as; the contractor not following the claim, no money transfers between the parties and so on (Dixit and Skeath, 2004).

4.2.1.5. Rationality

One basic assumption of game theory is that players are intelligent and rational. This means that each player has a will to act in his or her own self-interest and self-benefit. In other words, players who are capable of thinking at least probabilistically determine the outcome of their actions, and players are able to choose and rank outcomes for their self-interest (Romp, 1997). As a result, essential components of rationality are full knowledge of self-interests, and complete calculation of what actions produce best outcome for those interests (Dixit and Skeath, 2004).

4.2.1.6. Timing

The sequence of play and duration of the claim are the two topics of interest for the timing feature. In the strategic approach timing features, such as sequential versus simultaneous offers play an essential role in the analysis. In the sequential model, each party may offer and wait for the other player’s response. In simultaneous offers, their opponents cannot observe actions from either party, or it may not have influence on the opponent’s decision for players’ strategy (Lessani, 2016).

Duration also can affect the settlement analysis of the disputes. Disputes and claims have a finite length of time. Either party may withdraw the claim before the court date, the parties could settle, or the statute of limitations could legally prohibit a claim from being made at all (Lessani,2016).

4.2.1.7. Information

Information is defined as the knowledge that each player has for determining the equilibrium of strategies. “Each party’s information identifies which player knows what information, and at what stage of the claim. Examples of player information include factual evidence, opponent’s beliefs over verdict, or strength of the arguments. Each player information may vary at each stage of the game due to different sources of information, difference in assessment of damages or liability, attaining new updates on disputes, or parties may have private information on one or more aspects of a game." (Lessani, 2016).

Various knowledge and informational structures create varying strategic models for settlement dispute including perfect versus imperfect information games, symmetric and asymmetric information games, and consistent prior versus inconsistent prior information (Lessani, 2016).

In this study, it is assumed that complete information is available and known by the players.

4.2.1.8. Dominant Strategy, Nash Equilibrium, Pareto (in)efficiency

Best response to all the probable strategy preferences of all the other players is called dominant strategy. If all the participants play their dominant strategy in a game, dominant-strategy equilibrium exists (Carmichael, 2005).

Equilibrium exists whenever all parties play best strategies to others' responses. In fact, the players choose strategies which are best responses to each other *in Nash equilibrium*. Nevertheless, Nash-equilibrium strategy does not certainly state a best response to any of the other players' strategies. On the other hand, if playing their Nash preferences in a game, there would be no encouragement for all players to do anything else. In every dominant strategy and its equilibrium, the players are playing their best strategies for best responses to each other. Hence, every dominant strategy and iterated-dominance equilibrium must be Nash equilibrium as well. However, every Nash equilibrium does not mean dominant strategy equilibrium. As a result, even though there is not dominant strategy in the game, Nash equilibrium is possible (Carmichael, 2005).

Pareto optimality is an outcome where there is no possibility to improve one player's payoff without harming others' the payoff. On the other hand, *Pareto inferior* is an outcome dominated by another outcome. Pareto efficient and Pareto optimality is interchangeable (Carmichael, 2005).

4.2.2. Common 2 × 2 Game models used in the study

Two common 2×2 games (Prisoner's Dilemma, Chicken Game) are presented and their equilibriums are illustrated. This thesis covers noncooperative game theory with pure strategies. Pure strategy means that player chooses a definite strategy with a probability of 1 for in all the cases.

4.2.2.1. Prisoner's Dilemma

In this game model police suspects a boy and his girlfriend and both are taken to prison. Police do not have adequate evidence linking them to the murder even though there is ground that they were involved in kidnapping the victim. Therefore, they are separated and prevented from communicating to each other. Each prisoner has the two options; confessing or denying. The police explain them separately that they are being taken to prison for the kidnapping, presumably 3 years, even though neither of them confesses. Both boy and girl are then players involved in simultaneous-move game where each has only two actions as responses whether confessing or not confessing to the crime of murder. They also know that denying the allegations or no confession make them stay a 3-year prison sentence due to being involved in kidnapping. They also know that, if opponent confesses he/she stays a sentence of 1 year prison for coaction with the police. And, the other player stays in prison at least 20 years. If they both confess, they figure that they can negotiate for jail terms of 10 years each (Dixit and Skeath, 2004).

Cardinal payoffs in a normal matrix form are illustrated for Prisoner's Dilemma, in Table 4.1, which represents jail terms of years for each player in prison. There are two values in each cell. It demonstrates players' payoffs; former one in left represents 1st player's payoff and latter one in right represents 2nd player's payoff. Furthermore, each cell represents the strategies made by players. In Table 4.1, the better outcome is the one with lower payoff. In Table 4.2, cardinal form is substituted with ordinal form for Prisoner's Dilemma. In Table 4.2, ranking of payoffs for a given player is considered in a manner that the higher value is a more desirable outcome (Madani, 2009).

Table 4.1. *Cardinal Payoff Matrix in Prisoner Dilemma*

		Player 2	
		DC	C
Player 1	Don't Confess (DC)	3, 3	25, 1
	Confess (C)	1,25	10,10

Table 4.2. *Ordinal Payoff Matrix in Prisoner Dilemma*

		Player 2	
		DC	C
Player 1	Don't Confess (DC)	3, 3	1, 4
	Confess (C)	4, 1	2,2

Considering the prisoners' dilemma game the best outcome for the player appear as the player will confess and the opponent will deny, which results in the lowest payoff for opponent. What if 1st player believes 2nd player will deny? Again, the best strategy is to choice confess; 1st player gets only 1 year instead of the 3 that his own denial would bring in this case. Confess is better than deny for the 1st player or 2nd regardless of their belief about opponent's choice. In fact, confession (C) is the strictly dominant strategy for both players, which means that it is always better to confess whether opponent confesses or denies. However, if the players have a chance to prefer coaction where each player deny, and Confess (C, C) is Pareto-inefficient to (DC, DC) which is one Pareto efficient solution of the game. Thus, the payoff (C, C) which has lower value than the Pareto-optimal (DC, DC) but the payoff (C, C) is a Nash Equilibrium considering to the alternatives of other players, player cannot do any better by changing his tactic (Dixit and Skeath, 2004). At this stage, it is important to point out that Nash equilibrium is different than Pareto-optimality. Particularly, players who are interested in self-benefit, it seems that Nash equilibrium seems correct but not taking goodness of whole system into consideration. On the other hand, Pareto-efficiency is about system success without considering players' self-interest within the system (Madani, 2009).

4.2.2.2. Chicken Game

The two players represent motorists speeding towards each other. Each has the choice of either swerving to avoid a collision, or driving straight on. Table 4.3 shows the cardinal payoff matrix for drivers. If both drivers swerve then a crash is avoided and both players gain a pay-off of 30. If neither swerves, there is a head-on collision and players receive the smaller pay-off of -10. Finally, if one player swerves but the other drives straight on, the crash is again avoided. This time, however, the driver who was 'chicken' receives only 0, while the other receives 40 because of his or her bravery (Romp, 1997).

Table 4.3. *Cardinal Payoff Matrix in Chicken Game*

		Player 2	
		S	DS
Player 1	Swerve	30, 30	0, 40
	Don't swerve	40, 0	-10, -10

The outcomes for chicken game depend on how payoffs numbers for being hurt and crashing of the cars assigned. Each player most prefers to win, make others be chicken, and each least prefers crashing. In between these two undesirable, extreme outcomes, it is better to have your opponent be chicken with you (to save face) than to be chicken by yourself (Dixit and Skeath, 2004).

According to Table 4.4. , more analytical explanation is described for chicken game. The chicken game represents distributive type of negotiation in the state of winning or losing. There exists two Nash Equilibria; both are also pareto optimal, which are (Don Not Swerve, Swerve) and (Swerve, Do Not Swerve). The third Pareto-optimal resolution in the game is (Swerve, Swerve), optimal resolution, comes out where the players' payoff is more than two probable states with minimum payoff (3 > 2 = min

{2, 4}). This Pareto-optimal result (Swerve, Swerve) does not become a Nash equilibrium and can not exist when players give a decision dependent on their own interest. Playing exactly the opposite of strategy of opponent is the strictly dominant strategy in this game. Similar to Prisoner's Dilemma game, players have a willing to act free ride. Therefore, the cooperation for mutual solution ((Swerve, Swerve) in Chicken and (Don't Confess, Don't Confess) in Prisoner's Dilemma) is not stable, due to the fact that each player has willingness to refrain from it. On the other hand, if both players make decision for free riding, the payoff structure becomes the worst scenario for both of them in the game (Don't Swerve, Don't Swerve) while the payoff structure in Prisoner's Dilemma (Confess, Confess) becomes suboptimal, but not the worst scenario (Madani, 2009).

Table 4.4. *Ordinal Payoff Matrix in Chicken Game*

		Player 2	
		S	DS
Player 1	Swerve (S)	3,3	2,4
	Don't Swerve (DS)	4,2	1,1

4.3. Types of Negotiation

There are two main approaches, relatively distinct types, to negotiations adopted by the negotiating parties – distributive and integrative.

4.3.1. Distributive Negotiation

Communication seems to be more confrontational in the distributive type of negotiation. The parties generally have hidden agenda and do not share information or knowledge about their interests. The parties are prone to take contradictory positions in which they can either keep back or overstate reality about their problems, issues. Each player tries to manipulate through misdirecting, not complete and incorrect information or even discourage the opponent with bluffs or menace (Holbrook, 2010).

There are some threshold values, negotiating limits, in distributive negotiation: each participant has a target value, and a reservation value. A party could propose the initial offer in order to limit the opponent's desire for the range of negotiation, called anchoring. Parties do not explain its objective or reservation point to each other. The paricipants usually know there will be some backward and forward offers several times or steps after openning their personel target values. Generally, one party propose an offer and the opponent responds a counteroffer and so on, until they settle an agreement in possible agreement zone or result in deadlock due to being outside of the zone, Figure 4.1. Influence on the parties to revise and reconsider their positions is essential strategy during sequence of bargaining exchange. Each concession constricts range between target values (Holbrook, 2010). To be able to manage these steps and to control the progress, negotiators should have consciousness and awareness characteristics during the course of negotiation (Leritz, 1994).

In the construction disputes, target and reservation values are critical factors influencing the parties' decisions. Contractor's or Subcontractor's main target is to maximize his own benefit or minimize all of his losses. On the other hand, owner's objective is to make contractor complete the project within predetermined budget; that is, with the minimum extra payments, expenses in case of dispute occurrence.

- *Target Value* is the maximum value that participant tries to get from the negotiation. That is an ideal outcome. Parties' first proposals are target points (Raiffa, 1982).
- *Reservation Value and BATNA;* Reservation value can be stated as a barrier considering the worst result, payoff that a negotiator could accept. It means that further progress in a negotiation table is not possible due to final barrier. Moreover, the reservation point is not determined by parties' expectation but rather by what BATNA represents (Thompson, 2009). BATNA stands for Best Alternative to Negotiated Agreement (Fisher et al., 1981). Therefore, reservation point is closely related to BATNA, which is mainly a quantification of a negotiator's BATNA. Fisher (1981) concluded that

development of BATNA not only enables players to determine what a minimum acceptable agreement is; it would most probably increase that minimum. BATNA acts as a primary insurance policy. A well-qualified and clearly defined BATNA gives a negotiator the advantage to leave the negotiation table if it is obvious that a beneficial result is not possible.

- *Concession* can be stated as reductions that negotiator makes during the course of negotiation in the range between reservation value and target point.

Zone of Possible Agreement (ZOPA) is the range between reservation values of negotiator (Raiffa, 1982).

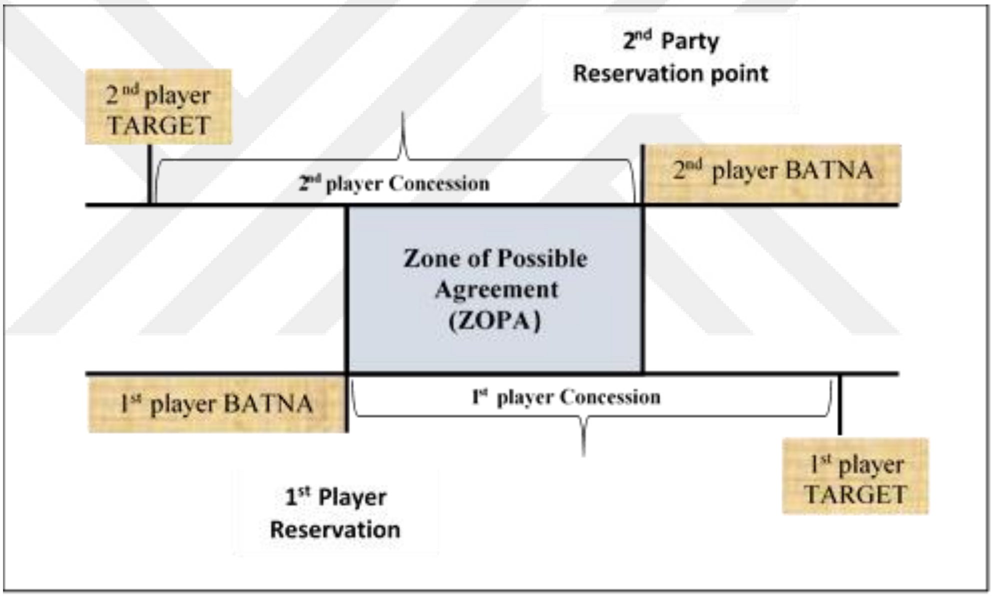


Figure 4.1. Geometry of Negotiation Zone (adaptad from Raiffa, 1982)

4.3.2. Integrative Negotiation (Principled Negotiation)

Integrative negotiation searches for various alternatives that meet the interest of both parties. Integrative negotiations require identification and understanding of their mutual problem, determine interests and generate possible options, and select one solution from the available alternatives (Lewicki et al., 2010).

Participants in integrative negotiation tell about common stories and meet satisfaction of participants' self-interest, which may require them to compromise (Holbrook, 2010). A wise agreement is the one that improves and sustains relationships, efficiently and amicably. Wise agreements satisfy interests of both parties. Considering construction industry, well-qualified and sustainable relationships are very important. Integrative type of negotiation can yield effective, wise agreement through principled negotiation developed by Fisher et al. (1981). This method has four basic points;

- ***Separation of problem from people;*** defining the issues clearly and addressing the problems without harming the relationships is important. This encourages them to have a clearer view of the substantive problem.
- ***Attention on interests, not positions;*** self-interests and benefits of parties should be satisfied through mutual agreement, which yields and end up asatisfactory solution. Awareness of human basic needs such as the need for security and economic well-being is significant at this stage.
- ***Discover alternatives for mutual payoff;*** Options are the potential agreements' points where compatibility and complementary of different level of interests can be achieved.
- ***Criteria, persistence on objective standard;*** when interests are directly conflicts, the parties are supposed to consider and bring objective criteria, standards in negotiation table to overcome their differences. Making decisions based on reasonable and independent criteria help players to agree and sustain their relationship. Legitimacy and practicability of such as positive science facts, professional criteria, or legal precedent. To succeed in objectivity, both parties should accept those criteria.

4.4. Negotiator in Contract Disputes

Generally, parties in negotiations send their representatives in order to discuss conflict, dispute without any help from neutral third parties. Hence, selection of the proper person to run negotiation processes and implement its essentials is one of the most vital steps. Being technically competent with the most knowledge about a dispute is not enough to participate in negotiations (Yates, 2011). Therefore, any individual to conduct effective negotiation is supposed to have some characteristics such as (American Council of Engineers Contractor's Guidelines to Practice, 1988);

- ability to plan properly and in detail,
- knowledge of topic,
- capability to comprehend the genuine interests of the parties,
- capability to think unmistakabaly and quickly under strain,
- capability to express considerations verbally,
- listening capability, patience,
- capability to inluence participants,
- capability to comprehend participants,
- capability to control feelings,
- capability to sustain adaptability

4.4.1. Negotiator as an Engineer

To have an effective negotiation skill is a prerequisite for today's project managers/engineers (Smith, 1992). Given their technical education, engineers might be ideal negotiators to conduct and negotiate engineering and construction disputes. On the other hand, most engineers are reluctant to be involved in dispute resolution process and do not have enough background about negotiation process, theories and strategies (Shapiro, 2012; Galloway, 2015). Instead, they visit their legal advisor to be the negotiator when disputes arise. Nevertheless, the engineer has many advantages over most individuals due to capability and ability to think in analytical forms. Particularly, as Galloway (2013) states, an engineer has great mindset thinking analytically and methodically through identification of all concrete data and presumptions to figure out the issue dependent based on problem-solving techniques. Ethics and license assigned to engineers during their education and professional life make them more trustful, which requires ideas and items based on concrete support for those ideas and work products. Moreover, engineers' capability to problem-solving can encourage them to find different choices uncovering those choices that are superior to others through a procedure of alternative assessment dependent on multiple criteria decision-making process (Galloway, 2013).

CHAPTER 5

A GAME THEORY BASED NEGOTIATION METHOD FOR DISPUTE RESOLUTION OF CONSTRUCTION PROJECTS

5.1. Development of the Proposed Method

Part of the participants' role in construction dispute is to identify dispute, comprehend the causes of dispute and handle it. Participants need to understand the basics of negotiation theories to be capable of dealing with this. Negotiation plays a critical role in resolution of disputes, and sustaining relationship among parties to a project.

In the scope of this study, it is intended to develop an effective alternative negotiation method for dispute resolution of construction projects. Game theory is selected as a core model for development of game theoretic negotiation approach due to dealing decision making of two rational opponents in the condition of conflict and cooperation, simulating different aspects of the conflict and predict the possible outcomes in absence of quantitative payoff information. Myerson (1991) specify game theory as the study of mathematical models of conflict and cooperation among rational individuals. It can be used in a various dispute contexts where participants are rational and desire to achieve the best possible outcome. This helps us think about participant's way of thinking in construction disputes as well.

Game theory based negotiation approach is to ascertain probable outcomes prior to arbitration or litigation and help participants to determine their strategy accordingly. Thus, following steps in the application of the proposed method supports them in participating negotiation at a definite time in dispute resolution management.

To accomplish this objective the proposed method covers mainly three research areas in an assemble logic and the method is conceptualized with five sequential steps.

Literature review on research areas are as follows;

1. Common Dispute Causes,

2. Analytic Hierarchy Process,
3. Negotiation Theory (Game Theory)

Steps of the proposed game theory based negotiation method in dispute resolution of construction projects are shown in Figure 5.1.

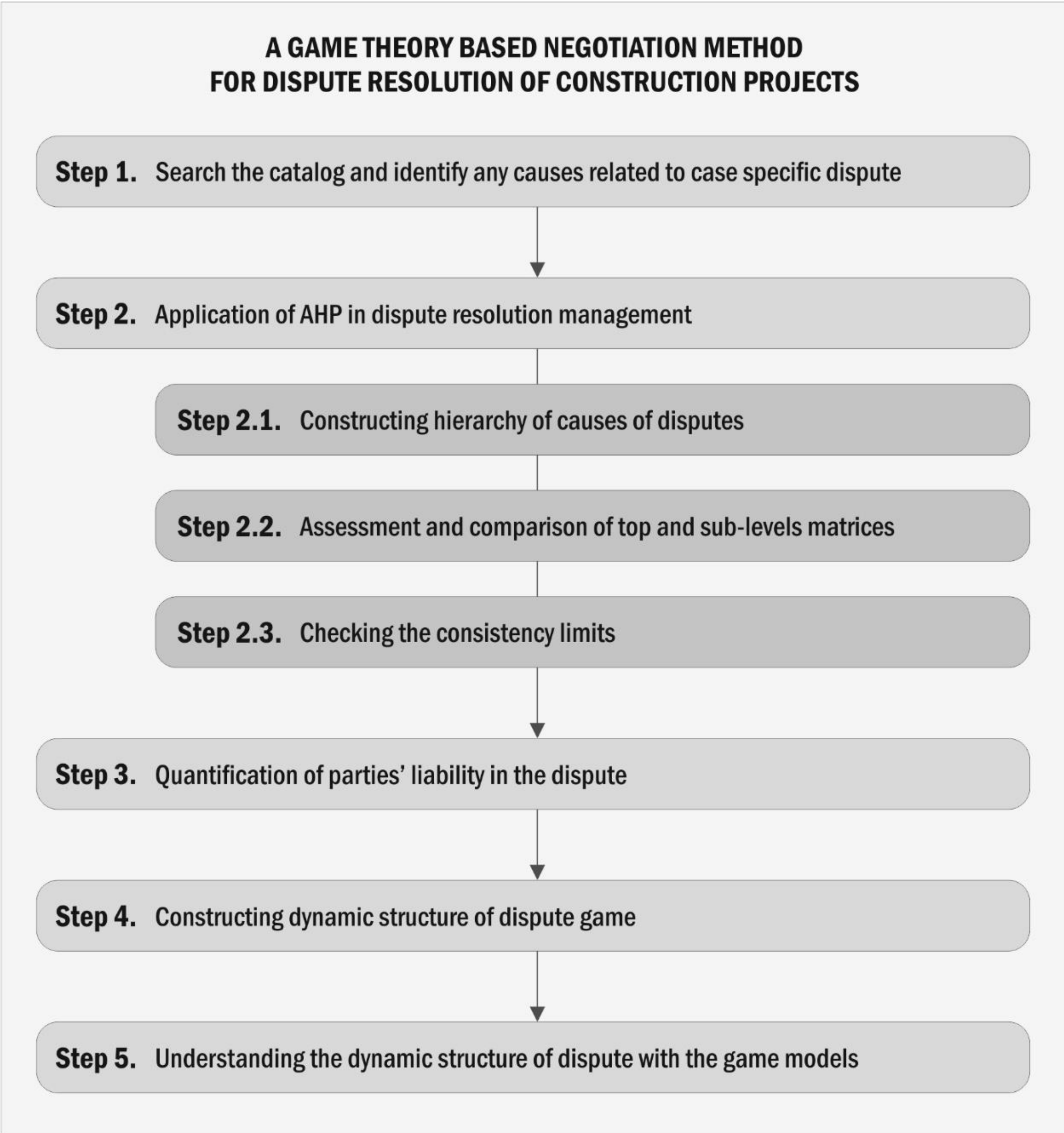


Figure 5.1. Steps of Game Theory Based Negotiation Method in Dispute Resolution of Construction Projects

5.1.1. Search the Catalog and Identify Causes of the Dispute Case

Firstly, clustered catalog for common dispute factors with a framework is developed through conducting literature review, as shown in Table 5.1. The purpose of clustering common causes of disputes in a framework is not to give all possible causes for all disputes within certain extent. Instead, any participant in dispute resolution process can benefit from it as much as possible to form a hierarchy of the causes or determine factors to make a proper analysis of the dispute. If necessary for the specific case, decision makers may consider new dispute causes, integrate those into, and evaluated with available ones in the catalog.

Table 5.1. *Clustered Catalog of common dispute causes*

No	IDENTIFIED COMMON DISPUTE CAUSES
1	Change orders
2	Interim payment delays
3	Acceleration
4	Slow or unauthorized decision making
5	Unrealistic imposed expectations
6	Interference
7	Delay in approving design documents
8	Delay in site handover
9	Lack of capable representative
10	Suspension of work by owner
11	Improper project feasibility study
12	Lack of experience in construction projects
13	Inadequate experience in planning and controlling
14	Incompetent project team
15	Delay in work progress
16	Insufficient financial sources
17	Poor communication and coordination with other parties
18	Lack of technical capability
19	Poor site management and supervision
20	Low quality of design;
21	Design errors and omissions
22	Design changes during construction
23	Inadequate / incomplete specifications
24	Insufficient data collection and survey before design

No	IDENTIFIED COMMON DISPUTE CAUSES
25	Inaccurate site investigation
26	Project design complexity
27	Ground conditions /site conditions
28	Unforeseen changes
29	Estimating Errors
30	Wrong selection of construction materials
31	Changes in material types and specifications
32	Quality of material
33	Poor procurement of construction materials
34	Labor shortage
35	Low skill levels, unqualified, inexperienced workers
36	Strike
37	Slow mobilization of labor
38	Low worker productivity
39	Shortages
40	Low efficiency
41	Breakdowns
42	Wrong selection or improper equipment
43	Lack of communication
44	Opportunistic Behavior
45	Negligence of project participants
46	Ambiguities and conflict in contract documents and different interpretations of the contract provisions
47	Weather condition
48	Legal issues; Changes in regulations and laws
49	Price fluctuations
50	Environmental concerns and restrictions.
51	Differing Site Condition; Surface and subsurface conditions
52	Delay in obtaining permits from municipality or any official entity.

5.1.2. Application of AHP in Dispute Resolution Management

Secondly, analytical hierarchy process is reviewed in literature. Selection of correct and important factors in making a decision in dispute resolution process is one of the most critical tasks. Moreover, ranking importance of dispute causes in a dispute process is prerequisite to solve complicated and unstructured dispute problems. In dispute subject matter, qualitative assessment should be considered with range of measurable quantitative factors. Hence, AHP is utilized, which enables users to ensure harmony of tangible (quantitative) and intangible (qualitative) factors in a solution for decision-making issues, systematically (Skibniewski et al., 1992). In this step, the main purpose is to achieve the most objective and unbiased ranking and weighting importance of dispute causes to calculate degree of parties' liability in dispute subject matter.

5.1.3. Quantification of Parties' Liability on the Dispute

In construction dispute, parties are usually involved in exchange of shared information and many facts. Moreover, they express their belief over the problem in their emails, official letters or other types of communication. Therefore, parties are generally aware of the dispute. As a result, liability distribution for each of the dispute causes can be evaluated by participant's belief over the identified causes. Determination of hierarchy of dispute causes and importance ranking of the causes contributing to development of dispute are critical to assess those causes rationally, systematically, and objectively in assessment of degree of parties' liability. After weighting the causes, participant can score them to compute degree of the liability for the parties in the dispute. Next, quantification of degree of parties' liability on the dispute subject matter becomes input value to effectively construct dynamic structure of dispute game, effectively.

5.1.4. Constructing Dynamic Structure of Dispute Game

In the course of construction of dispute structure in terms of cost and time dimensions, parties should be careful about identification of causes of disputes, effective performance of analytic hierarchy process and unbiased quantification of parties' liability in dispute. Furthermore, dispute is considered as the dispute amount (cost) in this part. Eventually and typically, outcome of disagreement is revenue loss as a cost almost in any type of dispute occasion.

Dispute structure is illustrated via graphical representation to clearly demonstrate the dynamics structure of dispute over the time, Figure 5.2. There are four important parameters to structure the dispute in the proposed method.

- *Dispute amount*
- *Quantified Parties' Liability*
- *Probable Cost (Revenue loss)*
- *Normal forms in ordinal payoff system.*

Dispute amount is the amount one party claims from the opponent party

Quantified Parties' Liability is calculated by dispute amount * degree of parties' liability.

Probable Cost is a revenue loss in failure of dispute. There could be many factors resulting in cost such as possible bank expenses, guarantee bond risk, expert's monthly fee, lawyer fee, head office expenses due to delay, expenses for opportunity of working capital, forfeiture of performance bond, equity of losing sustainable relationship, failure of getting possible other works and so on.

Normal forms with ordinal payoffs are mainly used for explanation of game models.

5.1.5. Evolution of Dynamic Structure of Dispute with the Game Models

In Chapter 4, negotiation is defined and different negotiation theories are introduced. Then, types of negotiation and their basics, prerequisites for development of unbiased and objective quantification of liability are described. Among negotiation theories, game theory is chosen as a core model to develop game theory based negotiation approach. In the course of a dispute resolution, various participants are involved in the process. Each party should consider the decisions given by all participants in the game. Thus, game theory is effective negotiation approach in such interactive and interdependent positions in which outcomes depend on participants' decisions and self-interests. 2*2 Game models, prisoner dilemma and chicken game, are introduced and explained in order to realize that there is a game structure in dispute cases on which those models can be strategically observed in the dynamic structure of dispute game, thereby participants can improve the way of their making strategic decision in dispute settlement negotiation. Dynamic structure of dispute game with distribution of equal liabilities is illustrated for the proposed method, which is a reference structure for explanation of different dispute game with partial distribution of parties' liabilities, Figure 5.2.

Figure 5.2 illustrates changes in payoffs over time for the players for the four probable results of the game ((Accept, Accept), (Accept, Don't Accept), (Don't Accept, Accept), (Don't Accept, Don't Accept)). In the equal liability distribution, the payoffs are similar to each other.

Dynamic structure of dispute game with distribution of equal liabilities is given as reference case for explanations of other cases with distribution of partial liabilities. Thus, parties are supposed to share dispute amount equally. At point A, there would be no risk of revenue loss at this stage. In Period 1, risk of failing in project increases and revenue losses grow if parties do not reach an agreement. Possible financial loss for parties is not more than the half of the dispute amount. In period 2, risk of financial loss of the project for parties becomes more than half of the dispute amount and more than the total dispute amount in the third period. The probability of financial loss is half of the dispute amount at point B and equal to dispute amount at point C.

Figure 5.3 and Table 5.3 illustrate how the structure of the dispute game evolves over time. The equilibriums and the Pareto-efficient results of the game vary due to alteration in dispute structure. At point A, Period 1 and Period 2; DA is a purely dominant strategy and (DA, DA) is the dominant strategy equilibrium, which is the solely Nash equilibrium, in addition to a Pareto-efficient payoff. In Period 1 and at Point B, the game has other Pareto-efficient results. However, game theory claims that owner and contractor are not willingly to accept their liability at this stage because of not equilibria. At point B, (A, A) and (DA, DA) are normally optimal results. On the other hand, based on a Nash proposed result (A, A) is not a probable solution of the dispute. In Period 2, in Figure 5.2, the question turns into a *Prisoner's Dilemma*. DA is purely dominant strategy and (DA, DA) is the dominant strategy and Nash equilibrium in addition to the Pareto-ineffcient payoff. Although (DA, DA) is Pareto-inferior to (A, A) where the parties share the dispute amount, players may make a decision not to accept any cost in this time interval. At point C, in Figure 5.2, DA is not pure dominant but still a dominant strategy (3 > 2 and 1 = 1) and there are three Nash equilibria ((DA, A), (A, DA), and (DA, DA)), two of which are Pareto-efficient ((A, DA) and (DA, A)). (A, A) is another Pareto-efficient result of the game. (DA, DA) is Pareto-inferior to all three Pareto-optimal outcomes. Game theory proposes that a player with a lower risk resistance can make a decision to take care of the dispute amount at this stage. If the players have the same risk resistance, they will end up not accepting any dispute amount and enter Period 3 of the game, in Figure 5.2, which finds *Chicken game* structure. In this period, one player chicken out and take care of the dispute amount to prevent high revenue losses from failure of the scrap yard project. Therefore, if parties realize objective assessment of their liability in dispute subject matter based on properly constructed dispute structure, they can prevent probable future revenue loss and dispute from the early stages of dispute (Madani, 2009).

Table 5.2. *Characteristics of the Dispute Game at Different Stage (adapted from Madani, 2010)*

Outcome (Si, Sj) Si,Sj S = {A, DA}	Payoff Ci(t), Cj(t)
(A, A)	Ci(t) = Half of the total dispute amount Cj(t) = Half of the total dispute amount
(A, DA)	Ci(t) = Total Dispute Amount Cj(t) = 0 (There is no probable financial loss to player j when player i pays for the dispute amount)
(DA, A)	Ci(t) = 0, Cj(t) = Total Dispute Amount
(DA, DA)	Ci(t) = probable financial loss to player 1 due to the failure of project
	Cj(t) = probable financial loss to player 2 due to the failure of project

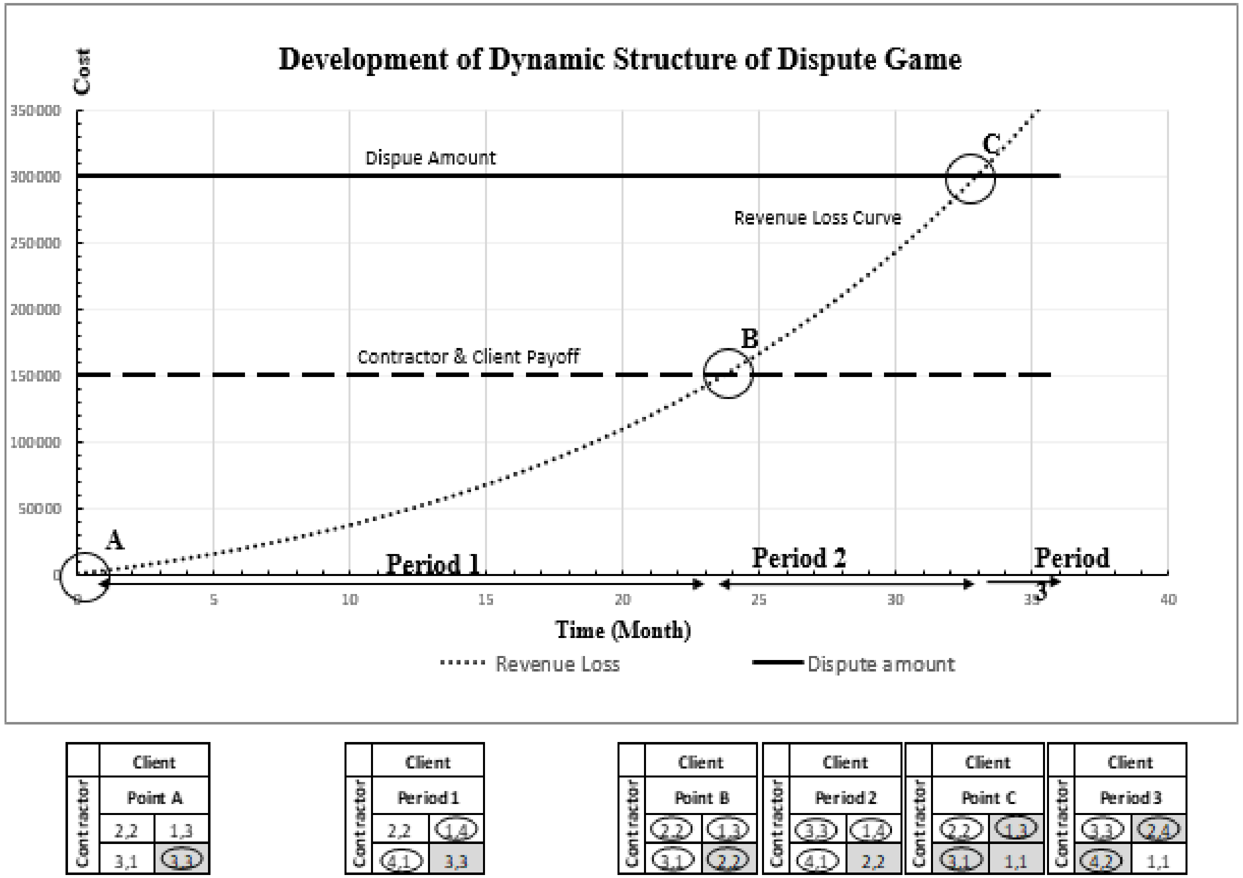


Figure 5.2. Dynamic Structure of Dispute Game: Equal Liability

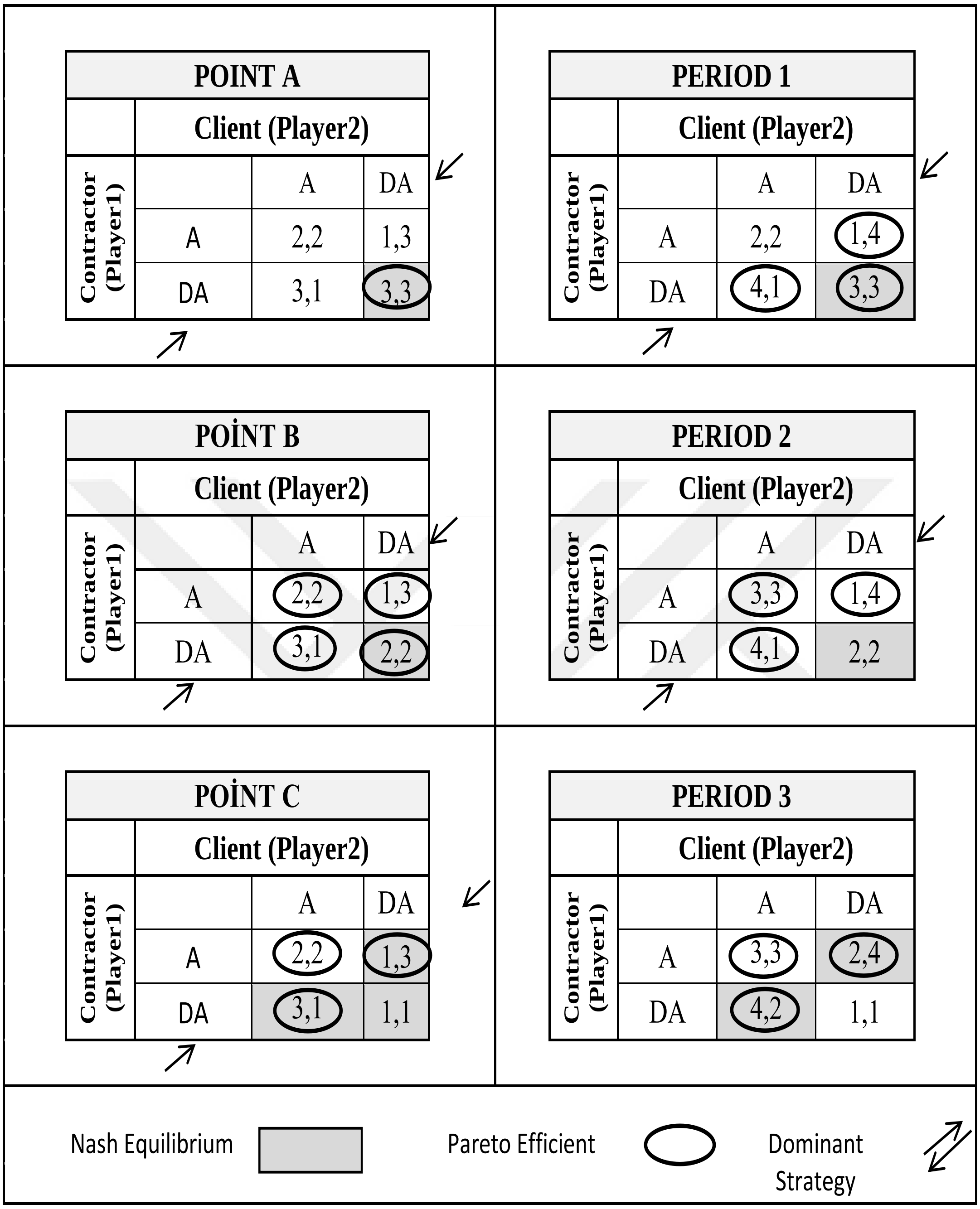


Figure 5.3. Scrap Yard Construction Dispute Game: Equal Liability

Table 5.3. *Possible outcomes and descriptions of payoffs in dispute (Adapted from Madani, 2010)*

Characteristics of the Dispute Game at Different Stage (%50-50)		
	POINT A	**PERIOD 1**
Strictly dominant strategy	DA	DA
Dominant Strategy	DA	DA
Nash Equilibria	(DA, DA)	(DA, DA)
Dominant Strategy Equilibium	(DA, DA)	(DA, DA)
Pareto optimal outcomes	(DA, DA)	(A, DA),(DA, A),(DA, DA)
	POINT B	**PERIOD 2**
Strictly dominant strategy	DA	DA
Dominant Strategy	DA	DA
Nash Equilibria	(DA, DA)	(DA, DA)
Dominant Strategy Equilibium	(DA, DA)	(DA, DA)
Pareto optimal outcomes	(AA),(A, DA),(DA, A),(DA, DA)	(AA),(A, DA),(DA, A)
	POINT C	**PERIOD 3**
Strictly dominant strategy	-	-
Dominant Strategy	DA	-
Nash Equilibria	(A,DA),(DA, A)(DA, DA)	(A,DA),(DA, A)
Dominant Strategy Equilibrium	(DA, DA)	-
Pareto optimal outcomes	(AA),(A, DA),(DA, A)	(AA),(A, DA),(DA, A)

5.2. Excel Tool for the Proposed Method

An excel tool is developed to make accurate and fast computation of pairwise comparison matrix forms. After forming hierarchy structure of dispute causes, shown in Figure 5.4, user-friendly excel tool can be easily utilized. Table 5.4 shows that participant can choose the number of causes as criteria to be processed. It also shows the pairwise comparison scale.

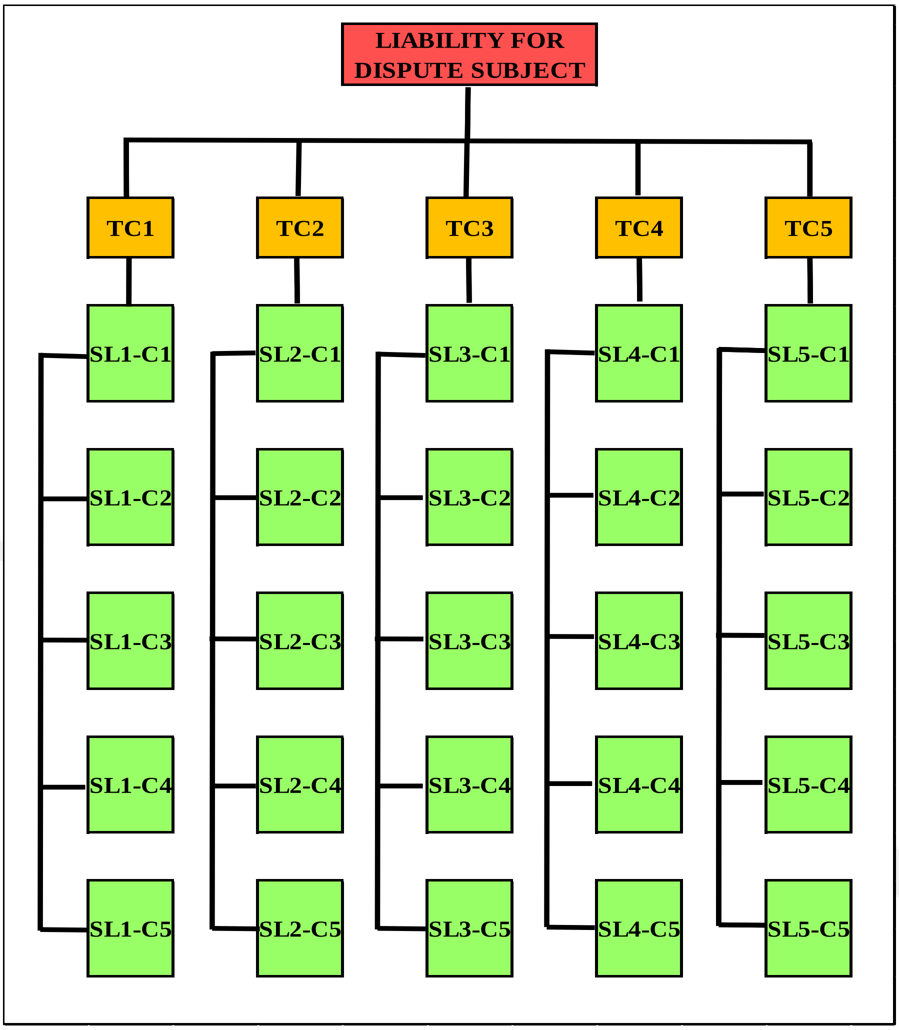


Figure 5.4. Hierarchy Structure of Dispute Causes

Moreover, as it is seen from Table 5.5, different decision makers, experts could have various criteria preferences in which their consistency ratio could also be different. Hence, Wu et al. (2011) revised AHP method for group decision-making is taken into consideration in case of more than one expert participation. It is formulated and integrated into the excel sheet according to steps explained and demonstrated in Chapter 3 literature on analytic hierarchy process. Normalized P is calculated according to their Consistency Ratio, (Table 5.5).

Table 5.4. *Selection of Number of Causes and Pairwise Comparison Scale*

AHP: Number of Causes	**5**
Fundamental Scale (Row v Column)	
Extremely less important	1/9
	1/8
Very strongly less important	1/7
	1/6
Strongly less important	1/5
	1/4
Moderately less important	1/3
	1/2
Equal Importance	**1**
	2
Moderately more important	3
	4
Strongly more important	5
	6
Very strongly more important	7
	8
Extremely more important	9

Each expert, participant can assign his name and evaluate the common negotiated causes by the help of a pairwise comparison matrix to rank importance of the dispute causes, (Table 5.5). The tool allows experts' assessment for each assembled pairwise comparison matrix forms, (Table 5.6).

In the same excel sheet there is a bridge for evaluation of sub-levels, which are evaluated in the same manner of top-causes, Table 5.7. That is, for each sub level, all assessments are following the same calculations, formulas and computation steps performed as in the top criteria assessment.

Table 5.5. *Selection of Number of Participants for Top Criteria Assessment*

TOP CRITERIA ASSESSMENT							Click Here
						Experts #	**3**
EXP	**EXPERTS' PAGES**	**EXPERTS' NAME**	**CR**	**Modified P* &Unormalized**	**Normolized P***	**Criteria**	1 2 3 4
1	1st Expt'!A1	EXP1	0.19639	0.33739	0.24073	**Criterion 1**	0.6529
2	2 nd Expt'!A1	EXP2	0.06456	0.60767	0.43357	**Criterion 2**	0.1530
3	3 rd Expt '!A1	EXP3	0.11907	0.45647	0.32570	**Criterion 3**	0.1545
4	4th Expt'!A1	EXP4	0.00000	0.00000	0.00000	**Criterion 4**	0.0249
				1.40153		**Criterion 5**	0.0147

Table 5.6. *Pairwise Comparison Matrix Assessment in The Excel Tool*

	Criterion 1	Criterion 2	Criterion 3	Criterion 4	Criterion 5	~~Criterion 6~~	~~Criterion 7~~	~~Criterion 8~~	~~Criterion 9~~	~~Criterion 10~~
Criterion 1	1	7	5	4	4	5	~~1~~	~~1~~	~~1~~	~~1~~
Criterion 2	1/7	1	1/3	4	1/5 1/4 1/3 1/2 1 2 3 4	~~3~~	~~1~~	~~1~~	~~1~~	~~1~~
Criterion 3	1/5	3	1	1		~~3~~	~~1~~	~~1~~	~~1~~	~~1~~
Criterion 4	1/4	1/4	1	1		~~3~~	~~1~~	~~1~~	~~1~~	~~1~~
Criterion 5	1/4	1/4	1/4	1/2		~~1~~	~~1~~	~~1~~	~~1~~	~~1~~
~~Criterion 6~~	~~1/5~~	~~1/3~~	~~1/3~~	~~1/3~~	~~1~~	~~1~~	~~1~~	~~1~~	~~1~~	~~1~~
~~Criterion 7~~	~~1~~	~~1~~	~~1~~	~~1~~	~~1~~	~~1~~	~~1~~	~~1~~	~~1~~	~~1~~
~~Criterion 8~~	~~1~~	~~1~~	~~1~~	~~1~~	~~1~~	~~1~~	~~1~~	~~1~~	~~1~~	~~1~~
~~Criterion 9~~	~~1~~	~~1~~	~~1~~	~~1~~	~~1~~	~~1~~	~~1~~	~~1~~	~~1~~	~~1~~
~~Criterion 10~~	~~1~~	~~1~~	~~1~~	~~1~~	~~1~~	~~1~~	~~1~~	~~1~~	~~1~~	~~1~~

Table 5.7. *Selection of Number of Sub-levels with Two Sub-Levels*

SUB-LEVELS ASSESSMENTS		# of SUB-LEVELS	Click →	2
SUB-LEVEL 1	**SUB-LEVEL 2**	**SUB-LEVEL 3**	**SUB LEVELS 4**	**SUB LEVELS 5**
CLICK HERE FOR ASSESSMENT	CLICK HERE FOR ASSESSMENT	CLICK HERE FOR ASSESSMENT	CLICK HERE FOR ASSESSMENT	CLICK HERE FOR ASSESSMENT
0.71409	0.54848	No Sub-level	No Sub-level	No Sub-level
0.09996	0.24091	No Sub-level	No Sub-level	No Sub-level
0.18595	0.21061	No Sub-level	No Sub-level	No Sub-level
0.00000	0.00000	No Sub-level	No Sub-level	No Sub-level
0.00000	0.00000	No Sub-level	No Sub-level	No Sub-level
0.00000	0.00000	No Sub-level	No Sub-level	No Sub-level

Using the processed weights of the AHP, numerical values are compared and dispute causes are prioritized by ranking importance of them. Once the hierarchy is created, participant can attain a numerical scale to each couple of options by making pairwise comparison with regards to their impact on the element placed in the higher level in the hierarchy. After computing the normalized weights for all defined dispute causes in the dispute hierarchy, participant can assess the contractor and owner by scoring them for degree of liability out of 100 percentage, which is quantification of distribution of parties' liability in dispute subject matter, Table 5.8.

Table 5.8. *Quantification of Degree of Parties' Liability*

*TC(Top Causes), *SLC(Sub-level Causes)			TOTAL CLIENT LIABILITY (%)	100	CONTRACTOR LIABILITY (%)	0
	#	Weights (W)	Scoring Client Responsbility	Client Responsbility	Scoring Contractor Responsbility	Contractor Responsibility
TC1		TC1-WEIGHT	100.00	100*TC1WEIGHT	100-100=0	0.00
	SL1-C1	Normalized W	100.00	100*Normalized W	100-100= 0	0.00
	SL1-C2	Normalized W	100.00	100*Normalized W	100-100= 0	0.00
TC1-WEIGHT	SL1-C3	Normalized W	100.00	100*Normalized W	100-100= 0	0.00
	SL1-C4	Normalized W	100.00	100*Normalized W	100-100= 0	0.00
	SL1-C5	Normalized W	100.00	100*Normalized W	100-100= 0	0.00
TC2		TC1-WEIGHT	100.00	100*TC2WEIGHT	100-100=0	0.00
	SL2-C1	Normalized W	100.00	100*Normalized W	100-100= 0	0.00
	SL2-C2	Normalized W	100.00	100*Normalized W	100-100= 0	0.00
TC2-WEIGHT	SL2-C3	Normalized W	100.00	100*Normalized W	100-100= 0	0.00
	SL2-C4	Normalized W	100.00	100*Normalized W	100-100= 0	0.00
	SL2-C5	Normalized W	100.00	100*Normalized W	100-100= 0	0.00
TC3		TC1-WEIGHT	100.00	100*TC3WEIGHT	100-100=0	0.00
	SL3-C1	Normalized W	100.00	100*Normalized W	100-100= 0	0.00
	SL3-C2	Normalized W	100.00	100*Normalized W	100-100= 0	0.00
TC3-WEIGHT	SL3-C3	Normalized W	100.00	100*Normalized W	100-100= 0	0.00
	SL3-C4	Normalized W	100.00	100*Normalized W	100-100= 0	0.00
	SL3-C5	Normalized W	100.00	100*Normalized W	100-100= 0	0.00
TC4		TC1-WEIGHT	100.00	100*TC4WEIGHT	100-100=0	0.00
	SL4-C1	Normalized W	100.00	100*Normalized W	100-100= 0	0.00
	SL4-C2	Normalized W	100.00	100*Normalized W	100-100= 0	0.00
TC4-WEIGHT	SL4-C3	Normalized W	100.00	100*Normalized W	100-100= 0	0.00
	SL4-C4	Normalized W	100.00	100*Normalized W	100-100= 0	0.00
	SL4-C5	Normalized W	100.00	100*Normalized W	100-100= 0	0.00
TC5		TC1-WEIGHT	100.00	100*TC5WEIGHT	100-100=0	0.00
	SL5-C1	Normalized W	100.00	100*Normalized W	100-100= 0	0.00
	SL5-C2	Normalized W	100.00	100*Normalized W	100-100= 0	0.00
TC5-WEIGHT	SL5-C3	Normalized W	100.00	100*Normalized W	100-100= 0	0.00
	SL5-C4	Normalized W	100.00	100*Normalized W	100-100= 0	0.00
	SL5-C5	Normalized W	100.00	100*Normalized W	100-100= 0	0.00

After completing first three steps, the distribution of degree of dispute liability is used in the constructing dynamic structure of dispute game. The dynamic dispute structure is presented by a graph as it was shown in Figure 5.2, on which evolution of the dispute structure with game models were observed and evaluated.

CHAPTER 6

DEMONSTRATION OF PROPOSED METHOD WITH HYPOTHETICAL CASE STUDY

6.1. Project Properties

Scrap yard project construction project (approximately 8000 m^2) located in Ankara/Turkey, is used as the case study. Information about the project is given below;

Delivery Method

- Works Construction

Project Duration

- 90 Days

Works main items according to given design descriptions:

- Rock Embankment (15-30 cm) and crushed stone filling on the rock embankment
- Boundary Wall and Wire Fence
- Plant mix base construction
- Asphalt Spreading

Project Design

- Designs given by Employer

Site Area and Soil Characteristic

- Silty Clay, mud and saturated soil, high level water table, and vulnerable to surface water

Employer Representatives

- Civil Engineer (Responsible for site), Less than 2 years' experience
- Architect (Responsible for administrative works), 5 years' Experience

Contractor

- More than 7 years experiences on building and superstructure works more years.
- No experience in road construction or asphalt spreading related works.

Contractor Representatives

- Civil Engineer, 10 Years - Experienced in construction industry,
- Civil Engineer, 5 Years - Experienced in construction industry, Site Manager.
- Administrators for the construction project, 7 years experienced in construction industry, Assistant to Site Manager.

Dispute Amount

- 300.000,00 TL

6.2. Stages of Dispute Development

a) *Water accumulations* are found in many local areas in Construction Site in the beginning of the schedule given by employer. Contractor is supposed to follow the schedule of works.

b) Excavator and trucks could *hardly work* to take out loam and mud from construction site. Eventually, construction site is cleaned and more than extra *one-week delay* occurred due to difficulties in working in the muddy ground. *Owner representatives informed* about water problem in construction site via pictures and during their site visit. However, this information is *not officially submitted* to owner.

c) Contractor pointed out that there is *no drainage system* to drain water from construction site. In addition, boundary walls are on same level in outside elevation. It means that the construction site is subject to surface water coming from high elevation of soil surface even after completion of the work. Therefore, contractor suggests two alternatives to cope with the problem.

- Increase height of the boundary wall to prevent surface water from coming into the scrap yard area.
- Application of Drainage Piping.

d) Owner responded to contractor;
   - Height of the boundary walls shall not be increased due to exceeding extra work's budget limit. Instead, the wall foundation shall be elevated upward about 30 cm over the permeable stone chips layer.
   - Drainage pipe shall be considered around the boundary wall but not inside of the construction site.

e) Then, contractor continues to work as he is directed and instructed. However, contractor read project design in a wrong way. Contractor brings *improper material* with size ranging 15 to 30 mm instead of filling material stipulated as 15-30 cm size. Basement of construction site compressed with improper/wrong material.

f) During the final stage of construction, construction of plant mix base asphalt spreading, the problem appeared dramatically. *Heavy trucks* bringing the plant mix materials to the site start to *sink* on the compressed layering material depth ranging 30 to 50 cm. (Two days before the final activity schedule, an extremely heavy raining and flooding of surface water to the site was anticipated).

g) Owner *suspends work* officially more than two months and revised the project on drainage system design. One construction company is invited to perform the application of drainage system.

h) Contractor takes off improper material and replaced with proper material stipulated in the technical requirements. On the other hand, economic instability of the country makes Turkish Lira depreciate against Dollar dramatically, by almost %50, during suspension of works. In addition, procurement of asphalt becomes very difficult from market and its price doubles. Contractor state that construction service is not possible to complete unless extra payment is considered. Contractor submits a claim for damages incurred due to error of design. Owner accuses contractor of selection of improper and wrong material resulting in unacceptable settlement occasion. Furthermore, owner also accuses contractor of not opening the site in the service, which causes economic losses in their cash flow.

i) Claims are not well managed and it turns into dispute. Damages incurred are approximately calculated as 300.000 TL.

6.3. Application of the Proposed Method

The proposed method requires five sequantial steps as follows;

Step 1. Search the catalog and identify any causes related to case specific dispute.

Step 2. Application of AHP in dispute management

- **2.1.** Constructing hierarchy of causes of disputes.
- **2.2.** Assessment and comparison of top and sub-levels matrices
- **2.3.** Checking the consistency limits

Step 3. Quantification of parties' liability on the subject matter

Step 4. Constructing dynamic structure of dispute

Step 5. Understanding the dynamic structure of dispute with the game models

6.3.1. The First Step of Proposed Method

Firstly, the clustered catalog is used to identify the causes related to case-specific dispute. Design errors and omissions, poor site management and supervision, insufficient data collection and survey, improper project feasibility study, lack of technical capability, inaccurate site investigation, and wrong selection of construction materials are selected as the main causes of the problem yielding dispute subject matter, as shown in Table 6.1.

Table 6.1. *Catalog of Common Dispute Causes*

No	IDENTIFIED COMMON DISPUTE CAUSES
1	Change orders
2	Interim payment delays
3	Acceleration
4	Slow or unauthorized decision making
5	Unrealistic imposed expectations
6	Interference
7	Delay in approving design documents
8	Delay in site handover
9	Lack of capable representative
10	Suspension of work by owner
11	Improper project feasibility study
12	Lack of experience in construction projects
13	Inadequate experience in planning and controlling
14	Incompetent project team
15	Delay in work progress
16	Insufficient financial sources
17	Poor communication and coordination with other parties
18	Lack of technical capability
19	Poor site management and supervision
20	Low quality of design;
21	Design errors and omissions
22	Design changes during construction
23	Inadequate / incomplete specifications
24	Insufficient data collection and survey before design
25	Inaccurate site investigation
26	Project design complexity
27	Ground conditions /site conditions
28	Unforeseen changes
29	Estimating Errors
30	Wrong selection of construction materials
31	Changes in material types and specifications
32	Quality of material
33	Poor procurement of construction materials
34	Labor shortage
35	Low skill levels, unqualified, inexperienced workers
36	Strike

No	IDENTIFIED COMMON DISPUTE CAUSES
37	Slow mobilization of labor
38	Low worker productivity
39	Shortages
40	Low efficiency
41	Breakdowns
42	Wrong selection or improper equipment
43	Lack of communication
44	Opportunistic Behavior
45	Negligence of project participants
46	Ambiguities and conflict in contract documents and different interpretations of the contract provisions
47	Weather condition
48	Legal issues; Changes in regulations and laws
49	Price fluctuations
50	Environmental concerns and restrictions.
51	Differing Site Condition; Surface and subsurface conditions
52	Delay in obtaining permits from municipality or any official entity.

6.3.2. The Second Step of Proposed Method

The proposed AHP has been demonstrated using the construction dispute case. Hierarchy consisting of the potential dispute factors was prepared as shown in Figure 6.1. The hierarchy structure was composed of three primary criteria, and two of which was subdivided into three levels. The related matrices were formed to direct the parties in making pairwise comparisons among the elements of the structure. The first pairwise comparison was made among the factors affecting the top level in the hierarchy. In this level, different dispute factors were compared to each other to quantify their ranking of importance on the overall dispute. In the case study, only three experts are participated in evaluation and the comparison of elements in the analytic hierarchy process. Finally, the consistency of the assessments in all reciprocal matrices was calculated, which are compatible with limits (Aminbakhsh, 2013).

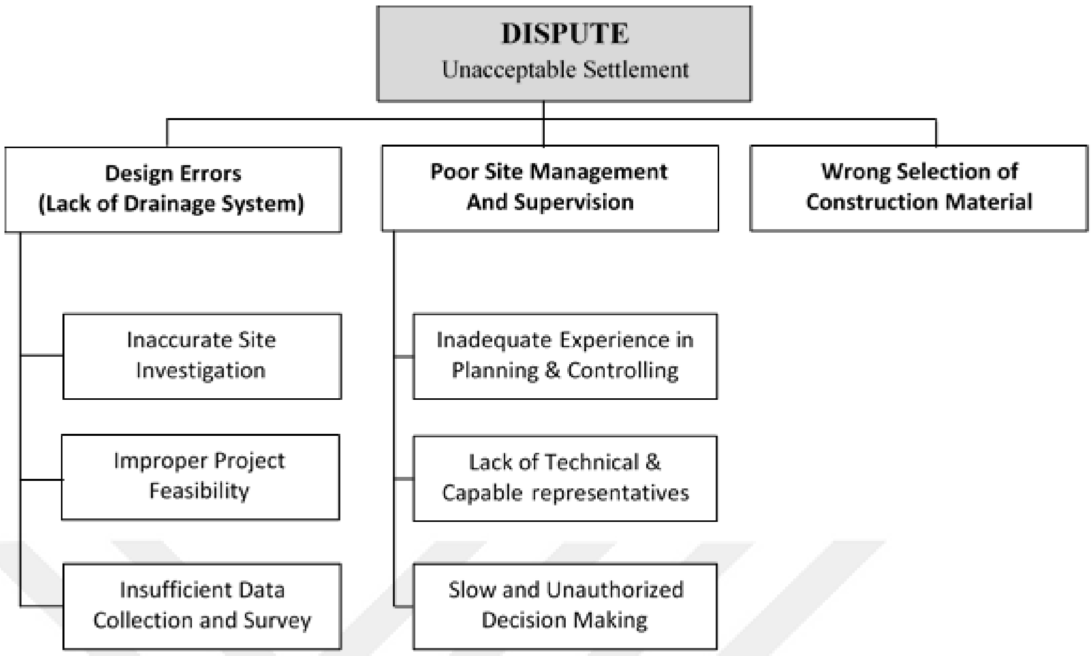


Figure 6.1. Hierarchy of Dispute Causes for the Case Study

In Table 6.2, assessment of comparison matrix by one expert for top and sub-levels criteria is presented to illustrate assignment of AHP pairwise comparison scale values. Consistency of assessments are cheched by comparing with the accepted threshold value in Table 6.3. Involvement of three experts in assessment of the comparison matrix for top and sub-level criteria and their consistency check are illustrated in Table 6.4, 6.5 and 6.6, respectively.

Table 6.2. *Assessment of Comparison Matrices for One Expert*

Top Criteria	Design Errors (Lack of Drainage System)	Poor Site Management And Supervision	Wrong Selection of Construction Material	WEIGHTS
Design Errors (Lack of Drainage System)	1	7	5	0,7235
Poor Site Management And Supervision	1/7	1	1/3	0,0833
Wrong Selection of Construction Material	1/5	3	1	0,1932
Sub Level 1	**Inaccurate Site Investigation**	**Improper Project Feasibility**	**Insufficient Data Collection and Survey**	**WEIGHTS* (Normalized)**
Inaccurate Site Investigation	1	7	5	0,5339
Improper Project Feasibility	1/7	1	1/2	0,0683
Insufficient Data Collection and Survey	1/5	2	1	0,1213
Sub-Level 2	**Inadequate Experience in Planning & Controlling**	**Lack of Experienced& Capable representatives**	**Slow and Unauthorized Decision Making**	**WEIGHTS* (Normalized)**
Inadequate Experience in Planning & Controlling	1	2	3	0,0457
Lack of Experienced& Capable Representatives	1/2	1	1	0,0201
Slow and Unauthorized Decision Making	1/3	1	1	0,0175

Table 6.3. *Checking Consistency Limits for One Expert*

Top Criteria		Sub-Level Criteria 1		Sub-Level Criteria 2	
CI	**CR**	**CI**	**CR**	**CI**	**CR**
0,033	0,057	0,007	0,012	0,009	0,016
Lambda	**Consistency OK**	**Lambda**	**Consistency OK**	**Lambda**	**Consistency OK**
3,066		3,014		3,018	

Table 6.4. *Assessment of Top Dispute Causes Weights with Three Expert*

TOP CRITERIA ASSESSMENT									Click Here
								Experts #	3
EXP	**EXPERTS' PAGES**	**EXPERTS' NAME**	**CR**	**Modified P* &Unormalized**	**Normolized P***			**Criteria**	**Weights**
1	1st Expt'!A1	EXP1	0.05674	0.63800	0.36717			**Criterion 1**	0.6324
2	2 nd Expt'!A1	EXP2	0.08206	0.54926	0.31610			**Criterion 2**	0.0883
3	3 rd Expt '!A1	EXP3	0.08170	0.55035	0.31673			**Criterion 3**	0.2793
4	4th Expt'!A1	EXP4	0.00000	0.00000	0.00000			**Criterion 4**	0.0000
				1.73760				**Criterion 5**	0.0000

Table 6.5. *Assessment of Sub- Level Dispute Causes Weights with Three Expert*

SUB-LEVELS ASSESSMENTS		# of SUB-LEVELS	Click ➡	2
SUB-LEVEL 1	SUB-LEVEL 2	SUB-LEVEL 3	SUB LEVELS 4	SUB LEVELS 5
CLICK HERE FOR ASSESSMENT	CLICK HERE FOR ASSESSEMENT	CLICK HERE FOR ASSESMENT	CLICK HERE FOR ASSESSMENT	CLICK HERE FOR ASSESSMENT
0.68134	0.57227	No Sub-level	No Sub-level	No Sub-level
0.13041	0.20464	No Sub-level	No Sub-level	No Sub-level
0.18825	0.22309	No Sub-level	No Sub-level	No Sub-level
0.00000	0.00000	No Sub-level	No Sub-level	No Sub-level
0.00000	0.00000	No Sub-level	No Sub-level	No Sub-level

Table 6.6. *Checking Consistency Limits for Three Experts*

	Top Criteria		Sub-Level Criteria 1		Sub-Level Criteria 2	
EXP 1	**CI**	**CR**	**CI**	**CR**	**CI**	**CR**
	0.0329	0.0567	0,0071	0,0012	0.0092	0.0158
	Lambda	**Consistency OK**	**Lambda**	**Consistency OK**	**Lambda**	**Consistency OK**
	3.066		3.014		3.018	
EXP 2	**CI**	**CR**	**CI**	**CR**	**CI**	**CR**
	0.0476	0.0821	0.0271	0.0466	0.0475	0.0820
	Lambda	**Consistency OK**	**Lambda**	**Consistency OK**	**Lambda**	**Consistency OK**
	3.095		3.054		3.095	

	Top Criteria		Sub-Level Criteria 1		Sub-Level Criteria 2	
EXP 3	**CI**	**CR**	**CI**	**CR**	**CI**	**CR**
	0.0474	0.0817	0.0475	0.0820	0.0270	0.0465
	Lambda	**Consistency OK**	**Lambda**	**Consistency OK**	**Lambda**	**Consistency OK**
	3.095		3.095		3.054	

6.3.3. The Third Step of Proposed Method

In development of the construction dispute, owner and contractor were involved in exchange of shared information. Indeed, they have expressed their belief over the problem in their emails, official letters. In addition, contractor have sent many pictures from the construction site through mobile application programs. Therefore, failure of drainage system as the primary cause of the dispute was officially submitted to owner's representatives during construction activities. Even though owner did not respond to contractor with permanent solution at the beginning, owner revised project of drainage system and made another contractor construct drainage system after some certain time. Therefore, parties are aware of the causes of dispute. Hence, each dispute causes can be scored by participant's belief over them. As a result, degree of parties' liability is obtained. Realistic assessment is performed based on available information in the given case study. Moreover, the Excel tool is utilized for accurate calculation and assignment of values. In Table 6.7, quantified degree of parties' liability for contractor and owner are computed, which will be used as one of the most crucial parameters to construct dynamic structure of dispute.

Table 6.7. *Quantified Degree of Parties' Liability in Dispute Game*

				CLIENT LIABILITY (%)	62.24	CONTRACTOR LIABILITY (%)	37.76
	#	Identified Dispute Causes	Weights	Scoring Client Responsbility	Client Responsibility	Scoring Contractor Responsbility	Contractor Responsibility
Design Errors (Lack of Drainage System)	**TC**		0.0000		0.00		0.00
0.6324	SL1-C1	Inaccurate Site Investigation	0.4309	90.00	38.78	10.00	4.31
	SL1-C2	Improper Project Feasibility	0.0825	100.00	8.25	0.00	0.00
	SL1-C3	Insufficient Data Collection and Survey	0.1190	100.00	11.90	0.00	0.00
	SL1-C4		0.0000	0.00	0.00	0.00	0.00
	SL1-C5		0.0000	0.00	0.00	0.00	0.00
Poor Site Management And Supervision	**TC 2**		0.0000		0.00		0.00
0.0883	SL2-C1	Inadequate Experience in Planning & Controlling	0.0506	20.00	1.01	80.00	4.04
	SL2-C2	Lack Of Technical & Capable representative	0.0181	40.00	0.72	60.00	1.08
	SL2-C3	Slow and Unauthorized Decision Making	0.0197	80.00	1.58	20.00	0.39
	SL2-C4			0.00	0.00	0.00	0.00
	SL2-C5			0.00	0.00	0.00	0.00
Wrong Selection of Construction Material	**TC 3**	**Wrong Selection of Construction Material**	0.2793	0.00	0.00	100.00	27.93
0.2793	SL3-C1		0.0000	0.00	0.00	0.00	0.00
	SL3-C2		0.0000	0.00	0.00	0.00	0.00
	SL3-C3		0.0000	0.00	0.00	0.00	0.00
	SL3-C4		0.0000	0.00	0.00	0.00	0.00
	SL3-C5		0.0000	0.00	0.00	0.00	0.00

6.3.4. The Fourth Step of Proposed Method

In the course of the proposed negotiation method, this step requires four significant parameters, as follows;

- *Dispute amount,*
- *Quantified Parties' Liability,*
- *Probable Revenue Loss as a cost,*
- *Normal forms in ordinal payoff system.*

Contractor claims for 300.000 TL for his damages incurred by owner, Figure 6.2.

- *Dispute amount*: 300.000, 00 TL

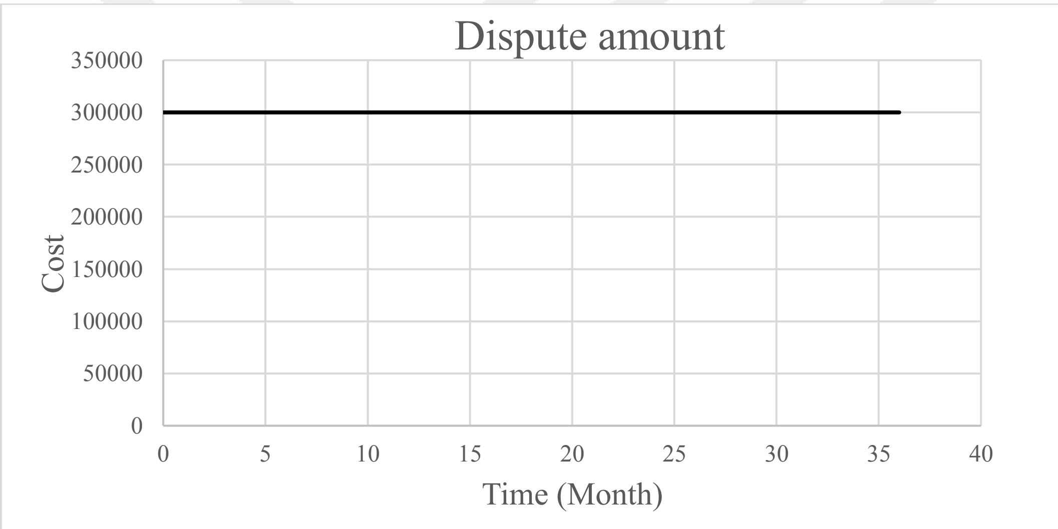


Figure 6.2. Dispute Amount Line

Quantified degree of liabilities is calculated as %37.76 and %62.24 for contractor and owner, respectively. According to distribution of degree of liability, owner's and contractor's payoff for the dispute amount are shown in Figure 6.4. It means that contractor is right for 186.720,00 TL payoff, which should be paid by the owner. Simultaneously, contractor should know that his claim, 300.000,00 TL, is not realistic and should be aware of that during positioning himself on dispute.

- *Owner: 113.280,00 TL (%62,24)*

- *Contractor: 186.720,00 TL (%37,76)*

In this study, it is assumed that parties' revenue loss flow per month is linear to each other. Probable Revenue loss as a cost shown in Figure 6.3. is assumed that it includes opportunity cost of working capital (1000 TL/Month), experts fee (1000 TL/Month), expenses of performance bond (500 TL/Month), off-site overhead cost (500TL/Month). Considering to high interest rates in Turkey Market, *%3* monthly compound interest rate is considered.

3000 TL/month (monthly compound interest rate %3)

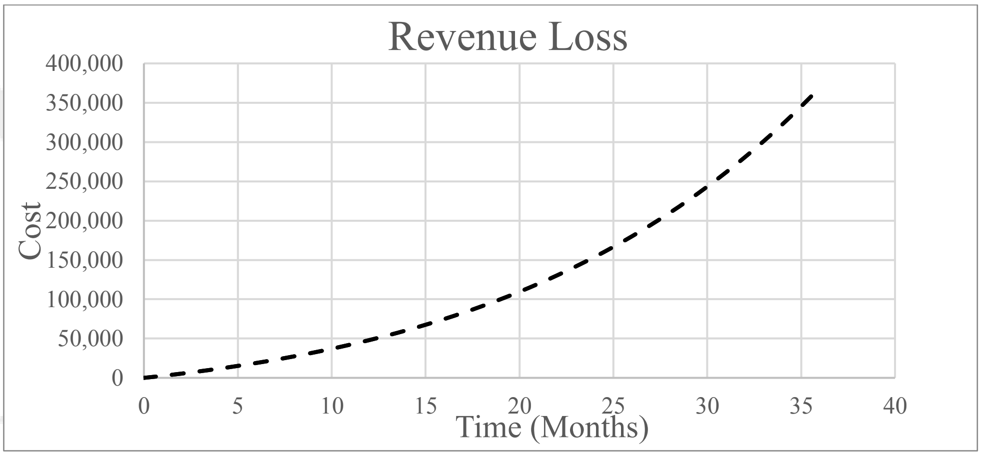


Figure 6.3. Revenue Loss Curve

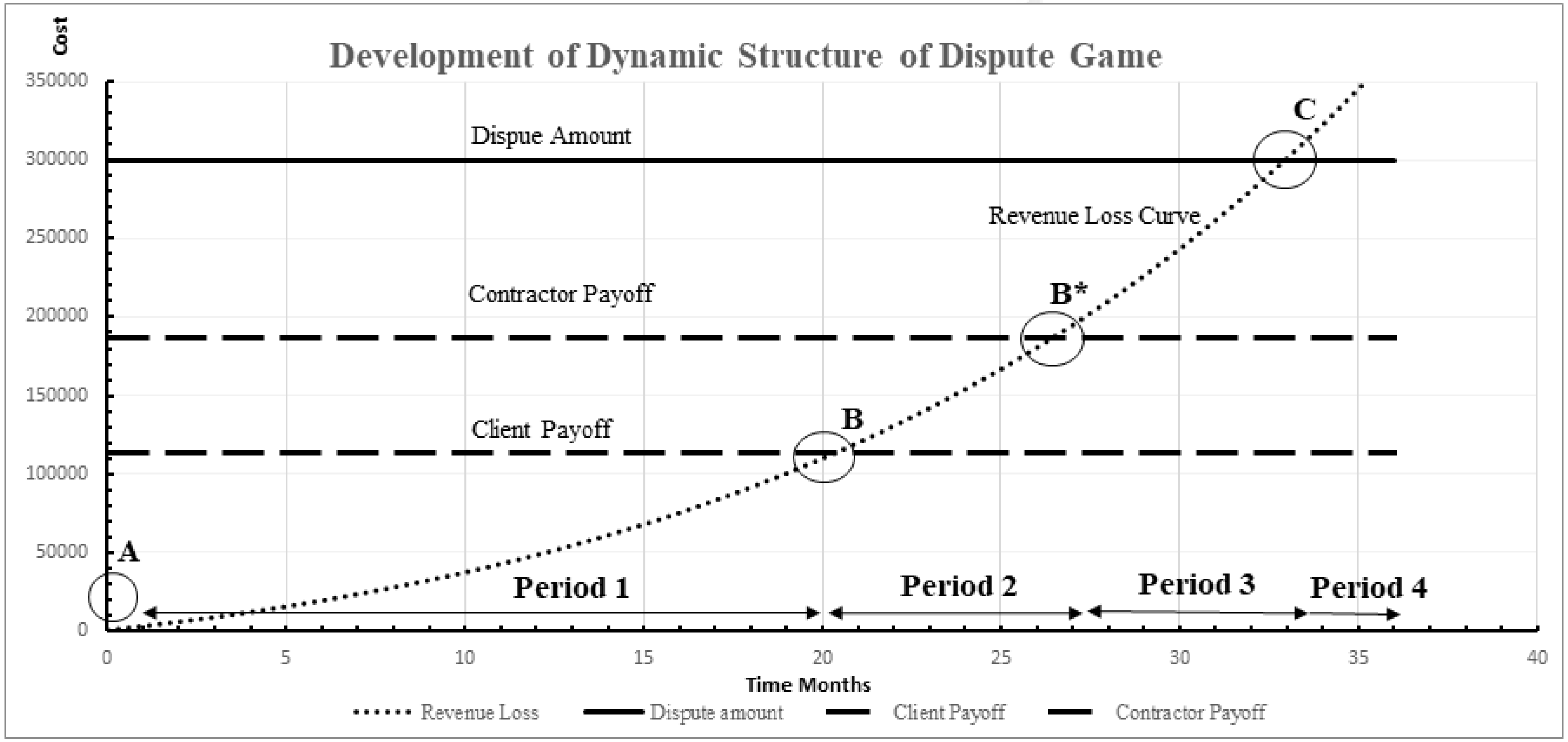
The last component of the construction of dynamic structure of dispute game is normal form of game models.

A stands for "Accepting". A* is payoff for "Accepting".

DA stands for "Doesn't Accept". DA* is payoff for "Doesn't Accept".

Table 6.8. *Normal Form of Game Model*

		Player 2	
		A	**DA**
Player 1	**A**	A*, A*	A*,DA*
	DA	DA*,A*	DA*,DA*



	Client	
Contractor	Point A	
	2,3	1,4
	4,1	(4,4)

	Client	
Contractor	Period 1	
	2,3	(1,5)
	(5,1)	4,4

	Client	
Contractor	Point B	
	2,3	(1,4)
	(4,1)	(3,3)

	Client	
Contractor	Period 2	
	(2,4)	(1,5)
	(5,1)	(3,3)

	Client	
Contractor	Point B*	
	(2,3)	(1,4)
	(4,1)	2,2

	Client	
Contractor	Period 3	
	(3,4)	(1,5)
	(5,1)	2,2

	Client	
Contractor	Period 4	
	(3,4)	(2,5)
	(5,2)	1,1

	Client	
Contractor	Point C	
	(2,3)	(1,4)
	(4,1)	1,1

Fiqure 6.4. Development of Dynamic Structure of Dispute Game

6.3.5. The Fifth Step of Proposed Method

Dispute cases typically evolve over time. As it is given in the following pages, in Table 6.9, changes occur in the dispute structure during different period intervals. Therefore, players' payoff functions can change, shown in Figure 6.6. Variation in game conditions can cause changes in structure of dispute (game), its equilibriums and outcomes explained by game theoretic models. Consciousness of dispute's course of development and changing circumstances provide beforehand warning knowledge of variation of dispute (game) structure, yielding better and effective negotiation at the table (Madani, 2009).

Awareness of payoff and dispute structure is a requirement to find rational resolution and useful perception into the dispute. In the case study, owner and contractor are involved in dispute on the last activity, asphalt spreading, to complete construction of scrap yard. Each has options of understanding the basics of dispute, realizing their liability contribution in development of dispute, or not accepting the claims and prolonging the dispute.

The case study was evaluated through the proposed game theory based negotiation approach.

6.3.5.1. Assessment of Case Study by the Proposed Negotiation Method

In the case study, parties' belief on the dispute factors are assessed to determine degree of parties' liability. Then, dynamic structure of dispute game is formed as is given in the following pages shown in Figure 6.5. At point A, there would be no risk of revenue loss at this stage. In Period 1, risk of failure of project increases and revenue losses grow if parties do not reach an agreement. Risk of revenue losses for parties is not more than % 37.76 and 62.24 % of the dispute amount for contractor and owner, respectively. In period 2, risk of financial loss due to failure of the scrap yard project becomes more than % 37.76 and less than %62.24 of the dispute amount. In period 3, probable financial loss due to failure of the scrap yard project becomes more than 62.24 % percentage and more than the total dispute amount in the fourth period. The risk of financial loss is %37.76 and %62.24 of the dispute amount at point B and B*, respectively and equal to dispute amount at point C.

As it is given in the following pages, Figure 6.6 and Table 6.9 illustrate how the structure of the dispute game evolves over time. The equilibria and the Pareto-optimal outcomes of the game change due to alteration in dispute structure. At point A, Period 1, Period 2, Period 3, DA is a strictly dominant strategy and (DA, DA) is the dominant strategy equilibrium, the only Nash equilibrium. At Period 1, period 2, point B and B*, the problem has other Pareto-optimal outcomes, but since they are not equilibria, game theory suggests that owner and contractor are unwilling to accept dispute amount at this point. At point B*, (A, A) is normally optimal outcome. On the other hand, based on a Nash solution outcome (A, A) is not a probable resolution of the dispute. In Period 3, Figure 6.5, the problem again turns into *Prisoner's Dilemma* structure. DA is still the strictly dominant strategy and (DA, DA) is the dominant strategy and Nash equilibrium. Although (DA, DA) is Pareto-inferior to (A, A) where the parties share dispute amount according to their distributed liability, parties could decide not to share any dispute amount in this period. At point C, Figure 6.5, DA is a dominant (not purely dominant) strategy (4 > 2, 4>3 and 1 = 1) and there are three Nash equilibria ((DA, A), (A, DA), and (DA, DA)), two of which are Pareto-efficient ((A, DA) and (DA, A)). (A, A) is another Pareto-efficient outcome of the game. (DA, DA) is Pareto-inferior to all three Pareto- efficient outcomes. As explained in the methodology, game theory proposes that a player who has a lower risk resistance could decide to take care of the dispute amount at this stage. If the players have the same risk resistance, they will end up in not accepting any cost and pass into Period 4, in Figure 6.5, which has the chicken game structure. In this period, one player will chicken out and bear the dispute amount to prevent high economic losses from failure of the scrap yard project (Madani, 2009).

To conclude, owner and contractor can develop a proactive dispute management by following the proposed method by which they can increase their consciousness and awareness of the possible outcomes and their payoff in advance. In fact, objective assessment for the quantification of degree of liabilities can be a reduction force if parties study and consider it in the first stage of dispute. Instead of positioning themselves on dispute amount inflexibly, they can consider the benefits and interest of outcomes according to dynamic structure of dispute game. Reactive response of parties on the dispute subject matter would not heal the issue. Instead, systematic, rational and scientific steps following the methodology in the proposed negotiation approach can reduce the tension and help disputants to resolve the issue, amicably.

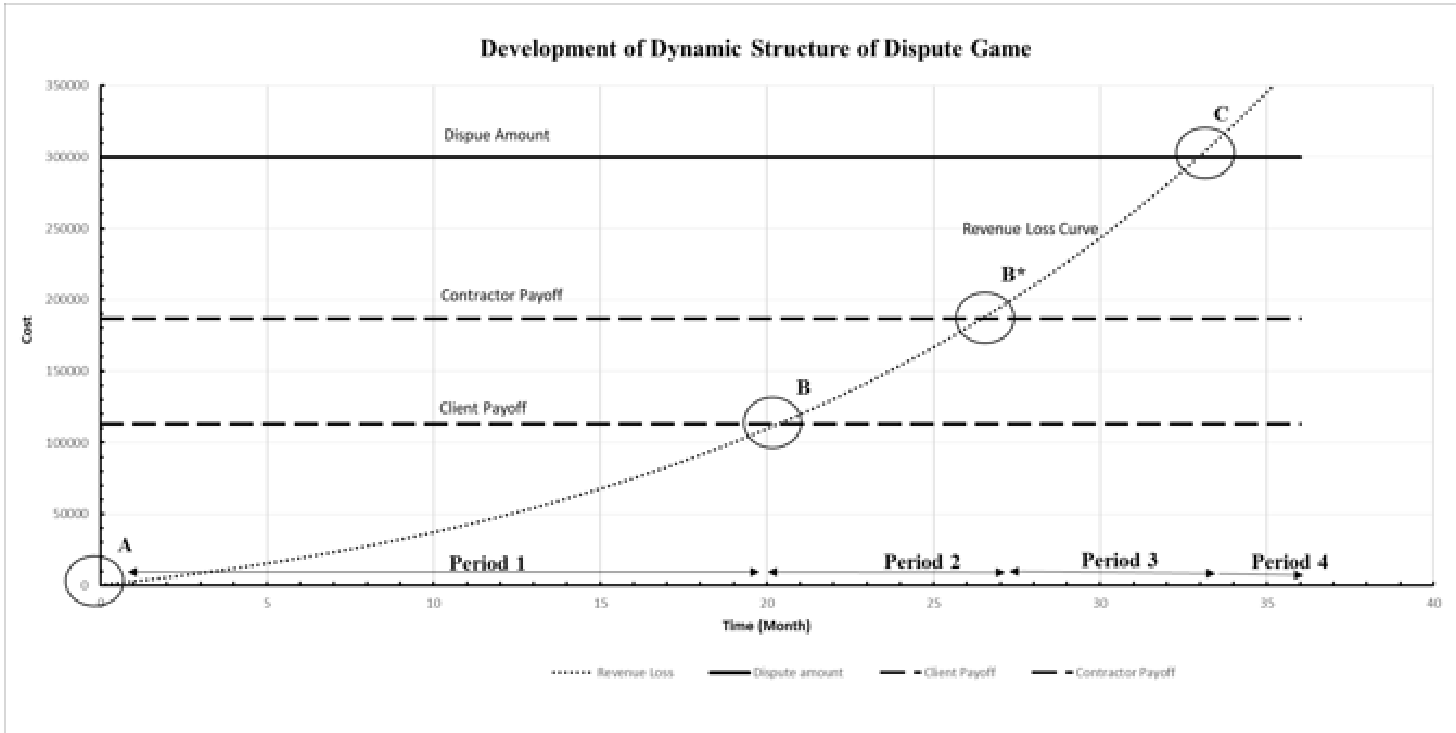
To illustrate, in period 4, owner should be aware of the fact that they could not make another contractor finish the rest of construction activities in the scrap yard project in case of termination of the contract due to litigation mechanism in Turkey. This is a rule set up by public procurement law. Owner revenue loss would increase dramatically due to not putting the area into service even though he could be more powerful than the contractor could. Simultaneously, if contractor becomes aware of the % 37.76 degree of liability for the issue, he can follow a principled negotiation, which could force his owner for the above-mentioned points about outcomes of period 4. In addition, contractor does also know that in this period revenue loss exceeds even his first claim amount, which is the worst scenario from his perspective. Conversely, owner might think that contractor could not afford the revenue loss during approximately lasting three years litigation period; thereby, owner could prolong the dispute, which is also an option for himself. However, it is known that the theory state that rational individuals try to maximize their payoff. Hence, even though it is an option, it could be just emotional response to make contractor suffer from the damage, which is not rational and not in the boundary rules of the proposed negotiation approach. Therefore, if both players get free ride in their own way, payoffs are the worst for both of them. Thus, this period is called as a chicken game. Hence, awareness of the structure of dispute game can force both parties searching reasonable resolution to the dispute if satisfactorily built by following steps of the proposed game theory based negotiation method.

Similarly, it is very significant to illustrate and explain the practicability of the dynamic structure of dispute game in the point B, period 2, point B* and period 3 for the case study. At this point, it is very crucial to have a knowledge about the fourfold pattern developed by Kahneman (2011) concluding that an individual is just as a risk seeking in the domain of losses and risk averse in the domain of gains. In period 3, the issue turns into prisoner dilemma structure. Precisely, it means that if parties cooperate, they can win together. Moreover, point B and B*, for the owner and contractor are the payoff based on quantification of degree of liabilities, respectively. If dispute comes to point B, owner starts to lose revenue due to increased risk of scrap yard project and contractor reach to same position at point B*. It would not be easy if they manipulate to each other to take advantage of time due to opponent rational way of thinking. If contractor insist on dispute amount and prolong the dispute until the point B, this is counterproductive behavior by which owner can start to become risk taker according to Kahneman (2011) result. This is also valid for contractor when dispute is not resolved in point B*. After that, without any hesitation, their cooperation is necessary to prevent the revenue losses in period 3, on which there is a pareto efficient solution in prisoner dilemma structure dispute game. If they are well informed about the proposed negotiation methodology with game models, they can take their position to solve the problem accordingly.

Therefore, awareness of the dynamic structure of dispute game makes participants search win-win options on negotiation table, particularly. If parties agree on the degree of liability for dispute, the dynamic structure shows how and why they need to cooperate or how and why they could fail in case of technical manipulation on the opponent party.

Moreover, with regard to the interval between the point B and B*, which is computed in accord with degree of liability of the parties, can become a zone of possible agreement (ZOPA), since degree of liabilities can result in internally computed reservation points instead of determined externally by best alternative to negotiated agreement.

In dispute cases, sometimes, one party do not want to come even together. On the other hand, professional life always allows parties to connect each other through official communication channels. Therefore, any party studying proposed negotiation method can convey information through illustrating possible outcomes and make opponent be aware of the facts. One of the rules of game theory is that people are well enough rational to maximize their interest. Therefore, principled and objective assessment of the proposed negotiation method can become a natural negotiation tool for bringing parties together at least on the negotiation table.



	Client: Point A		Client: Period 1		Client: Point B		Client: Period 2		Client: Point B*		Client: Period 3		Client: Point C		Client: Period 4	
Contractor	2,3	1,4	2,3	(1,5)	2,3	(1,4)	(2,4)	(1,5)	(2,3)	(1,4)	(3,4)	(1,5)	(2,3)	(1,4)	(3,4)	(2,5)
Contractor	4,1	(4,4)	(5,1)	(4,4)	(4,1)	(3,3)	(5,1)	(3,3)	(4,1)	2,2	(5,1)	2,2	(4,1)	1,1	(5,2)	1,1

Figure 6.5. Dynamic Structure of Dispute Game: Case Study

POINT A			
	Client (Player2)		
Contractor		A	DA
	A	2,3	1,4
	DA	4,1	4,4

PERIOD 1			
	Client (Player2)		
Contractor		A	DA
	A	2,3	1,5
	DA	5,1	4,4

POİNT B			
	Client (Player2)		
Contractor		A	DA
	A	2,3	1,4
	DA	4,1	3,3

PERIOD 2			
	Client (Player2)		
Contractor		A	DA
	A	2,4	1,5
	DA	5,1	3,3

POİNT B*			
	Client (Player2)		
Contractor		A	DA
	A	2,3	1,4
	DA	4,1	2,2

PERIOD 3			
	Client (Player2)		
Contractor		A	DA
	A	3,4	1,5
	DA	5,1	2,2

POİNT C			
	Client (Player2)		
Contractor		A	DA
	A	2,3	1,4
	DA	4,1	1,1

PERIOD 4			
	Client (Player2)		
Contractor		A	DA
	A	3,4	2,5
	DA	5,2	1,1

Nash Equilibrium   Pareto Efficient   Dominant Strategy

Figure 6.6. Scrap Yard Construction Dispute Game: Case study

Table 6.9. *Characteristics of the Dispute Game at Different Stage in the Case Study*

Characteristics of the Dispute Game at Different Stages(%62,24-%37,76)		
	POINT A	**PERİOD 1**
Strictly dominant strategy	DA	DA
Dominant Strategy	DA	DA
Nash Equilibria	(DA, DA)	(DA, DA)
Dominant Strategy Equilibium	(DA, DA)	(DA, DA)
Pareto optimal outcomes	(DA, DA)	(A, DA),(DA A),(DA, DA)
	POINT B	**PERIOD 2**
Strictly dominant strategy	DA	DA
Dominant Strategy	DA	DA
Nash Equilibria	(DA, DA)	(DA, DA)
Dominant Strategy Equilibium	(DA, DA)	(DA, DA)
Pareto optimal outcomes	(A, DA),(DA, A),(DA, DA)	(AA),(A,DA), (DA A), (DA, DA)
	POINT B*	**PERIOD 3**
Strictly dominant strategy	DA	DA
Dominant Strategy	DA	DA
Nash Equilibria	(A,DA),(DA, A)(DA, DA)	(A,DA),(DA, A)
Dominant Strategy Equilibrium	(DA, DA)	(DA, DA)
Pareto optimal outcomes	(A,A), (A, DA), (DA, A)	(AA),(A, DA),(DA A)
	POINT C	**PERIOD 4**
Strictly dominant strategy	-	-
Dominant Strategy	DA	-
Nash Equilibria	(A,DA),(DA, A)(DA, DA)	(A,DA),(DA, A)
Dominant Strategy Equilibrium	(DA, DA)	-
Pareto optimal outcomes	(AA),(A, DA),(DA, A)	(AA),(A, DA),(DA A)

CHAPTER 7

CONCLUSIONS

This chapter concludes the primary findings of the study by referring to the proposed game theory based negotiation method with quantification of liabilities in dispute resolution of construction projects.

In the scope of this study, it is intended to develop effective negotiation method in construction related disputes. The main objective of this study was to illustrate disputants how to ascertain probable outcomes of dispute in advance by orchestrating a closer harmony between qualitative and quantitative approaches, thereby improving their negotiation strategies accordingly. To achieve this goal, three important resaerch areas were studied; construction dispute factors, analytic hierarchy process and negotiation theories for development of proposed game theory based negotiation method. Precisely, in the scope of proposed method, those three main research areas are assembled in a logic and conceptualized with five sequantial steps.

In the first part of the study, clustering a common construction dispute factors in a framework is developed by conducting comprehensive literature review. Any participant in dispute resolution process can benefit from it as much as possible to determine factors and to form a reasonable hierarchy of the causes to make a proper analysis of the dispute.

In the second part of the study, analytical hierarchy process is reviewed in the literature. In this step, the main purpose is to enable participants to organize tangible (quantitative) and intangible (qualitative) considerations in a solution within the hierarchy structure. Hence, AHP is utilized to achieve the most objective and unbiased ranking and weighing importance of dispute causes to be evaluated in calculation of degree of parties' liabilities in dispute subject matter. The major conclusions derived as a result of this part of the study can be summarized as follows.

- The probability of the plaintiff/defendant being responsible for the dispute subject matter is computed systematically, scientifically and rationally in case of further dispute resolution processes, i.e., arbitration or/and litigation.
- Quantifications of parties' liability can be considered as reservation points in the geometry of negotiation zone. Even though Fisher (1991) says that reservation point is closely related to BATNA (Best Alternative to Negotiated Agreement), steps of proposed negotiation method could determine reservation points obtained through scientific, systematical and rational analysis within the context of the specific case. As a result, well-qualified and clearly defined reservation points give participants advantage to run the negotiation table in the manner of objective and righteous outcomes.

The last literature review area is on the negotiation theories. Game theory is chosen as a core model for development of proposed negotiation approach. This part of the study is a complementary of the quantification of degree of parties' liability to construct dynamic structure of dispute. It is known that construction dispute problems can evolve over time and change its structure significantly. To illustrate the changes dynamic structure of dispute game is constructed by four parameters: dispute amount, quantified parties' liability, probable revenue loss as a cost, normal forms in ordinal payoff system.

The major conclusions derived in the light of understanding the dynamic structure of dispute with the game models can be summarized as follows. Game theory models become a natural tool to illustrate probable participants' preferences and outcomes of the dispute game. Therefore, recognizing correct stage of the dispute is critical in construction dispute management and decision making process at negotiation table.

Parties can analyze different stages of disputes by following steps of proposed game theory based negotiation method. By analyzing different stages of the dispute, participants can foresee the reason why they should accept or not accept dispute amount at the early stages and be aware of outcomes of the cooperative or non-cooperative dispute game.

Furthermore, players engaged with dispute may not have a reasonable and comprehensive understanding of the problem, how the structure of the game may develop and evolve, to what extent they will be involved in, and the risk resistance of other player. In some cases, players do not have a clear foresight and they can make their choices based on the current conditions, without thinking about the future changes. If a decision maker has awareness of dynamic structure of the dispute game and is sure that he/she will eventually chicken out because the opponent has a higher risk resistance or is more aggressive, he might make a decision to accept dispute amount from the early stage of dispute to prevent probable high revenue loss in the future. But then, a player with perfect foresight about the future and a high-risk resistance may be willing to prolong the dispute and end up to the last period (Chicken stage) to constrain the other player to chicken out and take care of the dispute amount (Madani, 2009). Moreover, player can follow the principled negotiation based on the proposed negotiation method to solve the issue as righteously as possible through illustrating possible outcomes of cooperation in the dispute game.

To conclude, participants could understand the significance of productive criticism based on probable outcomes of proposed method, thereby improving conditions of negotiation table for dispute resolution of construction projects between the parties.

The proposed approach is not without limitations. For instance, in the scope of the game theory based negotiation method, it is assumed that all players are intelligent decision makers, focus on maximization of their own interest, and have complete knowledge on the payoff. To cope with those constrains, in a future study, game theory with mixed strategies, incomplete, imperfect or asymmetric information and different game models can be integrated into the study. In addition, recent developments in game theory pay more attention to the behavioral aspects of the players including bounded rationality, emotions, and intuitive decision-making. In fact, there is a considerable amount of experimental studies suggesting that people playing one-shot prisoners' dilemma games starts to cooperate at least some of the time. There have been a large number of conducted researches and experiments showing that subjects playing one-shot prisoners' dilemma games have been found to cooperate about half of the time (Camerer, 2003; Carmihael, 2005).

Furthermore, Bayesian belief network method can be taken into consideration in the hierarchy structure process, thereby providing a framework for modelling the relationships between dispute factors, and for capturing the uncertainty in the dependencies between those causes using conditional probabilities. Thus, the probability of a value of a weighted dispute factor in the BBN can be determined by the occurrence of change in other interrelated factors. As a result, it can be possible to obtain probability of degree of liabilities, which affects the expected values of the dispute amount to be shared between parties during dispute settlement. Moreover, it can also influence time intervals and length of the periods in the dynamic structure of dispute game.

Moreover, this study can be associated with artificial intelligence. Due to their efficiency, artificial intelligence and computerized systems can be developed that replace human involvement processes and interactions, in particular in the field of construction dispute resolution. Electronic discovery, document automation, contract analysis via machine learning and AI techniques might make negotiators think about future of negotiation process.

Finally, it is crucial to point out that modern capitalist system and classical economy process make people consider maximization of their profit in every situation, which exclude ethical frame and influence mindsets of individuals negatively on dispute issues. Therefore, it is a requirement to pay attention to philosophy of ethics. Ethical maturity could yield better results in dispute resolution among the individuals in a long term, which does not just prevent future costs, but also it can produce happier and safer social contract for any kind of dispute in the society.

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